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EVOLUTION OF THE HUMAN FOOT[1]

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The human foot is a product of the special demands made upon it in the course of human evolution. The causes which condition the foot of man lie especially in his upright posture and walk and consequently changed statical and mechanical relations. In order to clear the subject as far as possible, the author subjected the foot and in some instances the entire lower extremity, to a comparative and anthropological investigation. This extended to the total configuration as well as the individual components of the foot and to both the passive and the active organs of motion. The material studied consisted of macerated and raw skeletons of different primates, preserved animals, X-ray photographs and for man frozen sections in addition.

The primates, including man, are only in a certain sense plantigrade, since in all forms the region of the heel is elevated in walking and the weight rests exclusively (in standing, chiefly) upon the lateral edge of the sole. Only in standing is the heel used as an additional support in man and to all appearance as a partial support in higher apes. The bipedal condition of man is entirely different from that of birds, kangaroos and the biped primates. All these animals, especially the birds, are erected not in an extension-position, but in a position of more or less flexion, particularly of the proximal part of the extremity, whereby the femur is abduced from the trunk. Pronounced climbing animals also retain their squatting position while standing on the ground, the body posed in readiness for jump or climb. This is lost in man through his completely upright posture, which, however, affords a quicker and easier lifting and moving forward of the leg. The extreme extension-

[1] For further details on the subject see author's "Der Menschenfuss." *Z. f. Morphol. & Anthropol.*, XXII, Heft 1 & 2, 51–282, 102 fig. The present article was translated by Dr. Adolf H. Schultz.

position of man, which is expressed most particularly in the frontal plane, i.e. in the adduction of the femora, causes the femora to converge beneath the pelvis and to carry the trunk above them. In the biped flexion-position, on the other hand, as seen in birds, the trunk is suspended between the femora. The direction of the tibia in man is markedly influenced by the adduction of the thigh-bone. The latter forms a straight continuation of the mechanical femoral axis and an angle with the anatomical axis of the femur, pointing medially, so that there exists a physiological genu valgum position. In anthropoid apes, in contrast to man, the femur and tibia form an angle pointing laterally at the knee, so that the animal stands in a genu varum position. This difference is explained by the shape of the bones. In human femora the angle between the axis of the shaft and the tangent to the condyles varies around 80,° in monkeys and apes it is nearly a right angle, and in birds it increases up to 113.° Corresponding to this, the angle between the longitudinal axis of the tibia and the plane of its condyles amounts to 80° in anthropoid apes and to 90° in man. In the latter, therefore, the tibia, corresponding to the upright posture, stands practically perpendicular both in a sagittal and in a frontal plane, whereas even in upright anthropomorphi the tibia must point, from in front and laterally, backward and medially.

Through the shifting of the origin and insertion of muscles in relation to the lines of joints, marked changes in the arrangement and effect of the musculature of the lower extremity take place. This is shown especially well in the glutaeal muscles and in the flexors of the leg. The glutaeus maximus, for example, is a flexor and abductor muscle in lower primates, but in consequence of the upright posture in man it changes to an extensor and adductor, thus reaching into the field of action of the biceps femoris. In general the flexor muscles lose in effect and importance in man, thereby increasing stability and restricting the possibility of movements to a sagittal plane, at the same time augmenting the distance of excursion.

In typical climbing primates the foot, in relation to the lower leg, is posed in extreme supination. This causes the sole to be directed medially and so, together with the grasping position of the hallux, to become especially adapted for the clasping of branches. If the animals go on the ground they retain this supination-position of the foot. The angle between the longitudinal axis of the tibia and the articular surface on its distal end is 70° to 80° in anthropomorphs and in man 90.° Corresponding to this angle and to the relation in direction between the

tibia and femur, the trochlea of the talus, in both man and apes, lies horizontally. This orientation of the foot has to be used as a basis for the comparative study, as it is the normal position. In primates this supination-position causes the foot to rest with only its lateral edge on the ground. In comparing this with the human foot it is evident that the skeleton of the latter has retained this characteristic climbing position. When the trochlea of the human talus is oriented horizontally the distal tarsalia and the basal parts of the metatarsalia are deepest laterally and highest medially. This arrangment is somewhat hidden by the fixed adduction of the hallux and the lowering of the capitula of the metatarsalia to a level base, but it can be easily demonstrated in every frozen section through a foot posed in the normal position. This original supination of the human foot and the original flexed position of the lower extremity are likewise expressed in the form of the skeletal elements of the fetus. In the latter, the angles between the shafts and articular portions of the femur, as well as of the tibia, correspond to those in primates, and are not due to any accidental adjustment to conditions of space in the uterus.

In the architectural structure of the human foot-skeleton two vault-like arrangments, one transverse the other longitudinal, can be distinguished. The transverse vault consists of two arch formations. One of these, the "structural arch," is founded in the structure of the tarsal bones themselves and is present in all primates and originally also in all terrestrial vertebrates. This arch is accentuated by plantar processes on both the lateral and the medial row of tarsalia. These processes may be termed, in analogy to the hand skeleton, as eminentiae plantares mediales and laterales. The origin of this arch may be regarded as a consequence of the adduction of the toes and metatarsals towards the mid-axis of the foot, which becomes necessary in walking and may be interpreted as a clasping motion. The second arch, the "position-arch," is caused by the supinatorial climbing position of the primate extremity in which the structural arch is posed on its lateral edge when on a firm plane surface. In abandoning the climbing position and in the transition to a terrestrial mode of life, this original supination-position was retained, but then called for a new medial support. The latter was created by the medial sinking of the supination arch, which concerns chiefly the first ray; i. e., through the fixation of the adducted hallux the supinatorial position-arch is completed on its medial side.

The longitudinal vault in man is a typically human condition, caused by the fact that the anterior part of the foot forms, at the transverse tar-

sal joint, an angle with the posterior part, especially the calcaneus. In this position the joints are fixed. In consequence of this the tuber calcanei comes to rest on the ground while the neck of the calcaneus is directed upward. The angle of inclination of the calcaneus lies, most likely in all human races, between 20° and 30.° It has often been claimed that flat-footedness in the negro is a normal condition, but this assumption is absolutely incorrect. The supporting points of the skeleton are formed by the tuber calcanei and the capitulum of metatarsal bone V and the sesamoid bones underlying the capitulum of metatarsal bone I. The toes themselves are bent dorsally at their basal joints and support only with the tips of their distal phalanges which are curved toward the planta.

These conditions are entirely different in monkeys and apes. A longitudinal vault, in the sense of that found in the human foot, does not occur here. While in man the greatest height of the longitudinal vault lies in the region of the transverse tarsal joint, in primates it is just this region that rests on the ground when the foot is placed on a plane. The anterior portion of the calcaneus is, as X-ray photographs show, directed toward the planta. The point of support is here a strong tuberosity near the anterior end of the plantar surface, which may be termed tuberculum basale. Further points of support are formed by the tuberositas ossis cuboidei and metatarsi V. In place of a "heel support," we have here a complicated "cuboid support" with a convexity directed toward the planta and an elevated heel.

An anterior fixed point of support does not exist; in typical walking monkeys, such as the baboon, the toes can be moved dorsally in their basal joints, just as in man, so that in walking the foot rests essentially on the ball and on the anterior plantar ends of the distal phalanges. For anthropoid apes, on the other hand, it is practically impossible to bend the toes dorsally in the basal joints; in consequence they have to rest their weight on the ends of their more or less curved phalanges. However, since these are too weak to support the burden particularly while walking, they are, as a rule (?) bent to a fist and the fist itself is then used as an anterior point of support. The clasping character of the climbing foot is therefore well expressed in all primates; here exists an "anterior clasping arch" which includes, in a more or less marked and continous curvature, all skeletal parts, from the cuboid support to the end of the phalanges. This arch is most pronounced in Orang-utan but can be demonstrated even in walking monkeys, such as baboons. Since this clasping arch is to be looked upon as a characteristic condi-

tion of the climbing foot and therefore as an original property of the primate foot, a shifting of the statically and mechanically required parts must have taken place in a proximal direction.

All monkeys and apes must have a medial point of support for the foot both while standing and walking. This is achieved in part—as in the baboons and gorilla—through a strong development of the plantar processes of the tarsal bones, representing the eminentiae of the "structure-arch," or through a flexion towards the planta of the hallux which thus becomes pressed to the ground. In lower monkeys, especially in Cercopithecidae, tarsal, metatarsal, and phalangeal touch-pads are formed, corresponding to the various points of support. In Anthropomorphae the tarsal pads change into a general heel pad. In the places on the sole where tendons run over skeletal points of support, or where these points are simultaneously centers of rotation for the foot, sesamoid bones are present. In Gorilla and Orang-utan sesamoid bones are missing under the capitulum of metatarsus I, where in man they are especially strongly developed, corresponding to the medial point of support.

Through upright posture the center of gravity shifts backward on the tarsus, which presses the heel to the ground. Thus in man the heel becomes the chief point of support for the body while standing. Since all longitudinal formations of the foot skeleton run together in the calcaneus, this bone becomes the morphological kernel of the foot problem. A comparative morphological study of the calcaneus reveals the important fact that this bone is much broadened out backward and downward and that its medial surface contains in the diagonal of the bone a large muscle area lying between the flexor groove of the sustentaculum and the tuberculum basale. This area musculi quadrati plantae is missing in all monkeys. In these animals there is a strong process on the lateral side of the calcaneus, which may be called processus peronei, and which in this form is absent in man. The human tuber calcanei reaches far toward the planta, gradually increasing in width and strength, and possesses a special lateral process not found in any of the other primates.

If the outlines of the calcaneus of a baboon are drawn into the outlines of a human calcaneus, taking into account the natural position of this bone in the respective foot skeletons, one finds an increase in bulk exactly in the diagonal, reaching from the talus joint to the lateral process of the tuber calcanei. It is this diagonal which sustains the chief pressure. In the Gorilla and Orang-utan the general form of the calcaneus is the same as in the Cercopithecidae, except that it is longer

in the former and higher in the latter. While man gained a new lateral support on the tuber, in Gorilla the tuber is turned sidewise and rests on the lateral broad side instead of on the original narrow plantar side. A rotation of the tuber, and therefore of the calcaneus, which has been repeatedly insisted upon, did not take place in man. If the foot and leg are correctly oriented, and if it is considered that the processus medialis of the human tuber corresponds to the entire tuber of monkeys and apes, it is found that in man, also, the axis of the tuber has a lateral inclination. This orientation depends solely upon the direction of the Achilles tendon which in itself is determined by the origin of the soleus and the course of its muscle and tendon fibers.

In all primates, and indeed in most mammals, one finds on the lateral surface of the calcaneus a more or less marked hump or a corresponding projection. This has to be explained, according to its morphological significance, as sustentaculum fibulare, especially in consideration of its form in many marsupials, in which it articulates with the fibula. This processus peronei, which is characterized by the fact that the two peroneus tendons run over it, loses for the most part its independence in man and is submerged in the general lateral strengthening of the corpus calcanei. In the Gorilla the posterior portion (pars tuberalis) reaches to the tuber, being connected with it, while in man it becomes the processus lateralis of the tuber, contributing to the lateral broadening and strengthening of the new foot support—the tuber. Accordingly, one finds in this region in man very numerous variations which may lead to a completely independent formation of the processus lateralis and to its shifting distinctly forward and upward, as has been noted in a native Australian. The independent periostal ossification centers, which have been observed in the processus lateralis and occasionally also on the lateral side of the calcaneus, speak in favor of this view. The so-called processus trochlearis, so frequently observed, has no direct connection with the true processus peroneus, but is only a purely human variation; it is to be explained as an ossification in the tendinous sheath of the peroneus tendons.

A comparative study of the spongiose structure of the calcaneus in X-ray photographs and sections shows clearly, in the different arrangement of the systems of trabeculae, the original heavy pressure on the region of the tuberculum basale and its gradual substitution in man by the processus plantaris of the tuber.

The mode of regression of the anterior clasping arch can be read from the formation and arrangment of the human metatarsals and toes.

The metatarsal bones and basal phalanges still show, although to a varying degree, the original bend toward the planta. First of all the rotation in the metatarsals is evident; these are clearly twisted in their capitulum portions when compared with their basal parts and this in such a way that, considering their natural position in the "structure" and "position" arches, the capitula of metatarsals II to V point medially. Metatarsal bone I behaves in exactly the opposite way, pointing laterally. In this relation the old opposition of the toes toward the hallux is clearly expressed. The same arrangment is found, although to varying degrees, in all primates, and here the tendency is shown to place the toes more on their lateral sides when walking on the ground. From this it may be concluded that man's ancestor with his climbing foot acquired the faculty of standing and walking on the ground in much the same manner as recent primates.

In regard to the human toes, it may be mentioned that it is not so much that the hallux has been strengthened as that the lateral toes have been reduced. This reduction may be accepted as amounting to anywhere from 5/8 to 3/5 of the original toe length. A new orientation of the toes, according to a mid-axis running through the second, or through the second and third toes, has taken place, and this in consequence of the shortening of the toes, of the adduced and fixed hallux, and of the loss of the opposition-position.

A special and peculiar condition is found in the second and third toes. In surprisingly many individuals these two toes are joined by a so-called web formation, which extends more or less distally in the region of the basal phalanx. According to the literature, syndactylism in this region is a condition which is not rare also and may even include part of the middle phalanx. It can be both inherited and transmitted. This coupling of the two toes, which may be termed zygodactylism, is expressed also in the parallel position of the two corresponding matatarsal bones, and especially in the common tendon of the extensor digitorum longus, which, in contrast to the other toes, may not split into two branches for the two toes until it reaches the back of the foot itself. The flexor digitorum brevis also shows peculiarities in the course of its muscle fibers and tendons, which speak for the solidarity of the second and third toes. Such connection between these two toes occurs also in monkeys and apes, especially in Hylobatidae and here best developed in Symphalangus syndactylus. It is found also as a special characteristic in many marsupials, here again more particularly in climbing forms, so that Huxley and Dollo upon this observation

based their conclusion that all marsupials have evolved from climbing forms. All this seems to justify the conclusion that zygodactylism of the second and third toes is a special but heretofore unappreciated scansorial feature in the human foot. It is also interesting to note that, although this condition is of a rudimentary character, it is more advanced in man than in most of the other recent primates. A record by Boas, which is of special significance here, may be recalled, i.e. the observation of joined third and fourth fingers in the human hand; the syndactylism of these fingers, I have found from the recent literature, was in two cases hereditarily associated with syndactylism of the second and third toes.

The bend toward the planta in the transverse tarsal joint of the portion of the foot in front of the calcaneus is in man not a process of motion but a firmly fixed position. In the primate foot, however, movements in this joint are possible in both plantar and dorsal direction. The fixed position of the hallux, which has often been interpreted as the typical condition of the human foot in contrast to the foot of other primates, is only part of a general process which has taken place in quite a number of pedal joints. In comparison with the foot of monkeys and apes, the human foot, in the normal position of rest, shows the greater plantar flexion in the ankle joint and the greater pronation in the calcaneo-taloid joint. While the position of rest is one of supination in the primate foot, it is one of pronation in the foot of man.

An exact analysis of the position of the calcaneus in relation to the talus shows that the characteristic inclination of the human calcaneus is a natural consequence of this pronation which in itself is due to the upright position of the leg and the entire body. In comparison with the foot of other primates, the human foot suffered a marked loss in mobility in its other joints also. While the faculty of movement in all axes is a requirement for the climbing foot, it is the unmovable connection between the anterior and posterior points of support in the standing foot that gives the human foot, and therefore the entire body, a firm and safe foundation.

The contraction of the foot muscles under the action of gravity leads to a shortening of the foot and to a bending of its anterior portion toward the planta, which is analogous to a grasping motion on a plane surface. This angular bend, characteristic for the human foot, is a consequence of the changed conditions of transmission of body weight during the assumption of an upright posture and also of muscular traction, and is an adaptation to standing and walking on level ground.

The adduction of the hallux and its fixation are caused by the tendency to gain an unalterable medial and anterior support for the foot, which becomes the more necessary, since the center of gravity shifted in consequence of the stretched position of the entire extremity from the lateral to the medial side. In walking and in elevating the foot on the ball it is the great toe which bears most of the weight. If the hallux is movable, as in other primates, the opposition muscles of the hallux, especially the peroneus longus, have to contract in every attempt at walking, in order to press the great toe firmly to the ground, as in a grasping or clasping motion. This leads to a steadily stronger adduction of the hallux, together with a flexion toward the planta. The final fixation in this position corresponds to the fixation of the joints in the remaining region of the foot. The theory of Klaatsch, who explains the adduction on the basis of a special mode of climbing, has to be rejected, along with other reasons, on account of the fact that anatomical as well as physiological conditions for the possibility of movements contradict it. Furthermore, the adduction is an adaptation to standing and walking; it is not caused by climbing but by upright walking.

The musculus quadratus plantae is a specifically human formation. Only its lateral head corresponds to the muscle of the same name which occurs in all lower primates; in Anthropomorphs this muscle is at times entirely missing or reduced to a ligament. The medial head of the quadratus plantae is to be interpreted as the deep head of the flexor digitorum brevis, which in primates has its origin on the tendon of the flexor tibialis. In connection with the increase in height of the calcaneus, this origin shifts from the tendon to the medial surface of the calcaneus in the region of the area musculi quadrati plantae. Embryology as well as conditions of innervation, speak for this explanation.

In monkeys the lateral head has its origin in the processus peroneus of the calcaneus. During the shifting of this process in man to the lateral plantar side of the tuber the lateral head moves with its origin backward and downward, approaching in this way the region of the origin of the medial head, so that both components join to form one muscle.

Compared with the foot of monkeys and apes, the human foot, through the inclination of the calcaneus, possesses a high and broad heel. The physiological significance of this is similar to that of the heel of a shoe, i. e., it increases, in connection with the extended position of the lower extremity, the ease of walking, inasmuch as the heel elevates the center of gravity of the foot, thus facilitating and accelerating its

moving forward over the ball. The walk of anthropoids when standing erect and supporting themselves on the toes clinched in the form of a fist, is analogous to walking in shoes with the heel at the anterior end of the sole. Since the foot of these animals remains movable in its parts, and since the entire extremity in addition is bent in all joints, walking upright must necessarily be very laborious and slow or by bounds.

Concerning the phylogeny of the human foot, it can be stated that the few and incomplete parts of fossil foot skeletons that have been found show in their principal characters no marked differences from recent man. Thus the conclusions seems justified that these fossil Hominidae must have walked upright. The calcaneus of Aurignac man gives the impression of that of a recent European and has no resemblances whatsoever to the Orang type, as maintained by Klaatsch in regard to other skeletal parts. On the contrary the foot skeletons of Hottentots and Australians that have been examined show in part very primitive conditions; among these, however, there is no flat-foot formation. The inclination of the calcaneus in these races is absolutely human and otherwise, also, there are no special relations to the anthropoid type. The human form of foot shows in general a very uniform type, from which fact it can only be concluded that the Hominidae had a monophyletic evolution.

The comparative anatomical study of the foot reveals features which at times resemble those of the Anthropomorph type, at other times more those of the Cercopithecidae. It should be remembered, however, that the last mentioned group of primates is not a morphologically uniform one, but shows various forms of adaptation. The condition of zygodactylism speaks for the theory that the Hominidae must have formed very early an independent branch of primates, which must have passed by itself through Anthropomorph stage, without, however, having stood in closer relation to the recent anthropoid apes. In the structure of the foot man resembles most closely the Chimpanzee. It is probable that the Hominidae originated from forms with long legs, in which the statical conditions favored an upright walk on account of the length proportions between the posterior extremity and the trunk. All groups of recent primates with such proportions show the tendency towards upright walking.

MEASUREMENTS AND OBSERVATIONS UPON THE HUMAN AUDITORY OSSICLES

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This investigation was undertaken in an endeavor to provide, if possible, a few more data on the absolute size and characteristics of the adult human auditory ossicles. The literature, so far as available, is remarkably devoid of extensive observations even on the gross anatomy of the ossicles. This is true especially in contrast to the large amount of work that has been done on the development and comparative anatomy of these bones. The standard textbooks and dissection manuals of anatomy give the average length and weight of the adult ossicles, probably from secondary sources; Urbantschitsch, 1876, seems to have been the only one to measure a series of bones.

My investigation was suggested and guided by Professor Meyer, to whom I am very thankful. It is based upon a somewhat larger series than that of Urbantschitsch, but covers some of the same ground, with slightly different results and some new observations. The material used by me was obtained from the dissecting room during the course of ordinary class-room work, in addition to a considerable series of bones obtained from other sources. The history of the cadavers is not known well enough to attempt any correlation between the observed differences in the bones and the subjects from which they were taken. In the majority of cases the sex also is unknown so that no conclusions could be made upon this matter, nor could all the bones be considered in pairs. The series of ossicles examined consisted of 63 individual mallei plus 29 in sets; 65 individual inci plus 29 in sets; and 17 individual stapes plus 14 in sets. Measurements were made with a micrometer caliper and with an ocular micrometer in a binocular microscope.

Malleus

The measurement on the length of the malleus was taken from the tip of the head to the tip of the manubrium, by means of a micrometer caliper. This method made no allowance for the variation in length caused by the variation in size of the angle made by the manubrium with the head-neck. The shortest right malleus measured 7.40 mm. and

the shortest left 7.35 mm.; the longest right, 8.61 mm. and the longest left, 8.85 mm. The average length of 43 right mallei was 8.15 and of 47 left 8.17 mm., or practically the same, although the bones were largely miscellaneous.

The long axis of the head and neck intersects the long axis of the manubrium to form angles of varying size, as represented in figure 1. In each case the angle (EOB Fig. 1) was measured under magnification on a protractor. The location of the long axes was determined by placing small dots at a midpoint of the respective processes near the extremities. These points were then connected with a point at the middle of the body, at the junction of the short process, neck and manubrium. The latter point was so placed as nearly as possible in the midline of each of these portions of the bone, as shown in the figure. Unfortunately, approximately 6° must be allowed for errors in reading the angles, and in variations in marking the exact midpoint in each case. However there still is a considerable difference in the size of the angles in different bones even after such a large allowance for errors.

The angles formed by the long axis of the head and neck with the long axis of the manubrium also varied. The largest angles were 151.5° and 156.° in the right and left malleus respectively. The smallest angle on the right was 125° and on the left, 122°. The average angle in 43 mallei from the right side was 139.3°, and in 46 from the left 139.8°. The greatest variation in this angle occurred in the bones of the left ear, although the average angle is very slightly smaller than in the bones from the right ear.

The variations of the angle EOB may be due to varying degrees of inclination of the tympanic membrance, which makes an angle of about 55° with the lower and anterior wall of the external acoustic meatus. According to Cunningham, 1915, the tympanic membrane is more oblique in cretins and deaf mutes and more perpendicular in musicians. According to Howell, 1915, the plane of the tympanic membrane makes an angle opening downward of 150°. How much the slope of the tympanic membrane varies and to what extent it causes the malleus to be shaped, I do not know, but it does not seem improbable that the two are related.

The size of the angles between the head and neck and the manubrium shows no direct relation to the total length of the bone in a small series measured. It appears from these figures that the variations in the length of the bone due to the great differences in the angles is smaller than at first might be presumed, as the following table shows.

TABLE 1

No. of bone	Length of bone	Angle bet. long axes of head and neck, & manubrium	No. of bone	Length of bone	Angle bet. long axes of head and neck, & manubrium
8	7.95 mm.	128.0°	23	8.18 mm.	149.0°
2	7.99 "	140.5°	17	8.36 "	125.0°
14	8.05 "	148.0°	28	8.40 "	150.0°
7	8.10 "	128.0°	24	8.57 "	155.0°
30	8.11 "	129.0°			

The greatest medio-lateral diameter of the head of a mallus was 3.05 mm. on the right, and 2.88 mm. on the left. The shortest diameter was 2.21 mm. on each side. The average diameter in 44 right mallei was 2.55 mm. and the average in 48 left 2.50 mm. The greatest diameter in an antero-posterior direction was 2.5 mm. on the right and

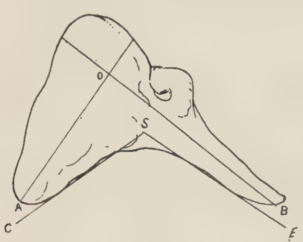

Fig. 1

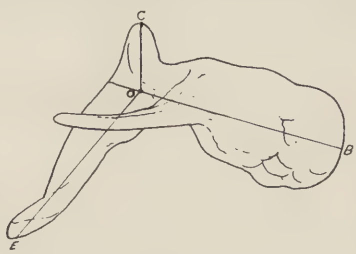

Fig. 2

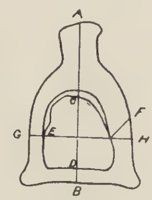

Fig. 3

Fig. 1. Sketch of malleus to illustrate the method of obtaining the angles. Angle EOB is made by the long axis of head neck with the long axis of the manubrium. Angle COB and COA are made by the long axis of the short process with the long axis of the head neck and the manubrium, respectively. (Enlarged.)

Fig. 2. Sketch of incus to show the method of obtaining the angles. Angle AOB is the internal angle formed by the two processes of the incus. Angle CSE is the external angle formed between the adjacent sides of the two processes. (Enlarged.)

Fig. 3. Sketch to illustrate the measurements on the stapes.
AB length of stapes
CD Length of opening between the crura
EF Width of the opening
GH Width of the bone across the two crura. (Enlarged.)

2.3 mm. on the left. The smallest was 1.5 mm. on the right and 1.7 mm. on the left. The average diameter in 44 right bones was 1.85 mm. and of 48 left bones 1.89 mm.

There appears to be no absolute relation between the length of the bone and the massiveness of its head, except that the size of head

usually increases with an increase in size of the bone. Nor was any definite relation noticed between the differences in the angles formed by the head and neck with the manubrium, and the size of the head.

The ratio between the medio-lateral diameter of the head and the total length of the malleus is 3.06, and that between the antero-posterior diameter 4.14.

The greatest length of the manubrium as measured from the tip of the short process to the tip of the handle (Fig. 1, CE) was 5.76 mm. on the right, and 5.80 mm. on the left. The shortest length was 4.25 mm. on the right and 4.30 mm. on the left. The average in 42 right bones was 4.9 mm. and that in 47 left bones practically the same.

The greatest length of the manubrium as measured from the mid-point of the base of the short process to the tip of the handle (OE Fig. 1) was 5.50 mm. on the right and 5.40 mm. on the left. The shortest length was 4.20 mm. on the right and 4.10 mm. on the left. The average of 42 right bones was 4.6 mm. and that of 47 left bones again practically the same.

The greatest length of head and neck as measured from the extremity of the head to the tip of the short process was 5.80 on the right side and 5.3 on the left. The shortest length was 3.7 mm. on the right and 3.5 mm. on the left. The average in 43 right bones was 4.6 mm. and that in 48 bones 4.5 mm.

The above figures give some indication of a variation in direction of the short processes. As a rule the tip of the short process extends to a higher level than the superior margin of the manubrium. When measured from the tip of the short process the manubrium averages 0.3 mm. longer than when measured from the superior edge of the head near the base of the short process to its extremity. As shown below this difference probably is due to the different angles that the long axis of the short process makes with the long axis of the manubrium. Whether, as has been suggested, the differences in length from the short process to the tip of the manubrium, and the attendant lengthening or shortening of the chords of the arcs formed by the cone-shaped tympanic membrance, due to variation in position of the umbo, affect the delicacy of the transmission of sound waves, I am not prepared to say.

The smallest angle formed by the long axis of the short process of the malleus with the long axis of the manubrium, (COE Fig. 1) was 94.0° on the right and 93.5° on the left. The largest angle was 145.0° on the right and 146.0° on the left. The average angles in 42 right bones was 123.9° and in 46 left bones 124.1°, or practically the same.

The greatest angle formed by the long axis of the short process with that of the head and neck (angle COB, Fig. 1) was 115.0° on the right and 116.0° on the left. The smallest angle was 80.0° on the right and 81.0° on the left. The average in 43 right bones was 94.7° and in 47 left bones 97.6°, a difference of 2.9°.

I foun d the average weight of 44 mallei some of which had not been carefully cleaned, to be 24.98 mgm. Poirier and Charpy 1907 gave a weight of only 22.26 mgm. and Howell and "average weight of 23 mgm." These differences in weight may be due mainly to the different methods used in cleaning the bones and to the number examined.

Incus

The greatest length of the posterior process of the incus measured from the most prominent part of the articular surface of the body to the tip of the process, was 5.69 mm. on the right and 6.17 mm. on the left. The shortest length was 4.4 mm. on the right and 4.5 mm. on the left. The average in 42 right bones was 5.2 mm. and that in 49 left bones the same.

The greatest length of the anterior process of the incus measured from the proximal margin of the articular surface of the body above to the tip of the process on the lateral side was 5.23 mm. on the right and 5.12 mm. on the left. The shortest length was 4.21 mm. on the right and 4.33 mm. on the left. The averages of 41 right bones was 4.7 mm. on the same in 48 left bones.

The greatest thickness of the body of the incus in a medio-lateral diameter was 2.50 mm. on the right and 2.6 mm. on the left. The least thickness was 1.8 mm. on the right and 1.6 mm. on the left. The average in 43 right bones was 2.05 mm. and in 49 left, 1.99 mm.

The greatest width of the body of the incus in a caudocephalic direction was 3.9 mm. on the right and 4.1 on the left. The least was 3.4 mm. on the right and 3.3 mm. on the left. The average width in 43 right bones was 3.8 mm. and in 49 left, 3.6 mm.

In order to determine the angles formed by the two processes of the incus with each other a point 0 Figure 2, was marked on the body near the articular surface as nearly in the middle as possible. The two lines connecting this point with the midpoint of the tip of each process form an angle (AOB Fig. 2) designated as the internal angle. The greatest internal angle in right inci was 86.5° and in left 80.5°. The smallest angle in right inci was 61° and in left 61.7°. The average in 43 right bones was 76.5° and in 49 left bones 71.3°.

The external angle CSE Figure 2 formed by the two processes of the incus can be determined approximately by two lines parallel to the adjacent surfaces of the processes. The greatest angle on the right was 122° and on the left 105.5°. The smallest angle on the right was 86° and that on the left 77,5°. The average in 43 right bones was 99.2° and in 49 left bones 95.0°. These angles were found to vary more than is usually stated but the average lies rather closely to the figures usually given. Gray 15 gives 90–100°, Cunningham 16 90–100°, and Poirier and Charpy '11 100–105°.

The average weight of 63 inci was 27.8 mgms. as compared with 25 mgms. given by Poirier and Charpy and by Howell.

There seems to be no direct relation between the variations in the length of the two processes and the angles made by them or the massiveness of the bone. The posterior process is appreciably longer and heavier than the more slender anterior process.

STAPES

The greatest length of the stapes taken from the articular surface of the head to the vestibular surface of the foot plate (Fig. 3 AB) was 3.7 mm. on the right and 4.4 mm. on the left. The smallest distance was 3.1 mm. on the right and 3.0 mm. on the left. The average in 11 right bones was 3.5 mm. and in 19 left bones 3.4 mm.

The greatest width of the opening between the two crura, measured at the middle of each crus (Fig. 3 EF) was 2.0 mm. on the right and 2.[illegible] mm. on the left. The smallest width was 1.2 mm. on the right and 1.4 mm. on the left. The average in 11 right bones was 1.7 mm. and the same in 19 left bones.

The greatest width of the stapes at the middle (Fig. 3 GH) was 2.9 mm. on the right and 2.8 mm. on the left. The smallest width was 2.0 mm. on the right and 2.1 mm. on the left. The average of 11 right bones was 2.4 mm. and of 19 left bones 2.3 mm.

The width of the stapes is largely dependent upon the curve of the two crura. When each crus is bent rather widely with a pronounced outward convexity the opening will be increased and if one crus is nearly straight but the other markedly bent the opening may be almost as large as in the first case. If both crura are nearly straight, the opening between them is reduced in width by 0.75 mm. in some cases.

The height of the opening varies independently of the width. It was measured from the lowest part of the arch formed by the edges of the two crura to a line on the inner surface of the foot plate (Fig. 3, CD).

Usually the arch formed by the posterior edges was lower. This length may vary from twice the width to slightly less than its width. The following will serve as illustrative cases.

Bone No. 200	Width of opening	1.5 mm.
	Length of opening	2.9 mm.
Bone No. 213	Width of opening	1.8 mm.
	Length of opening	1.7 mm.
Bone No. 214	Width of opening	1.8 mm.
	Length of opening	1.7 mm.

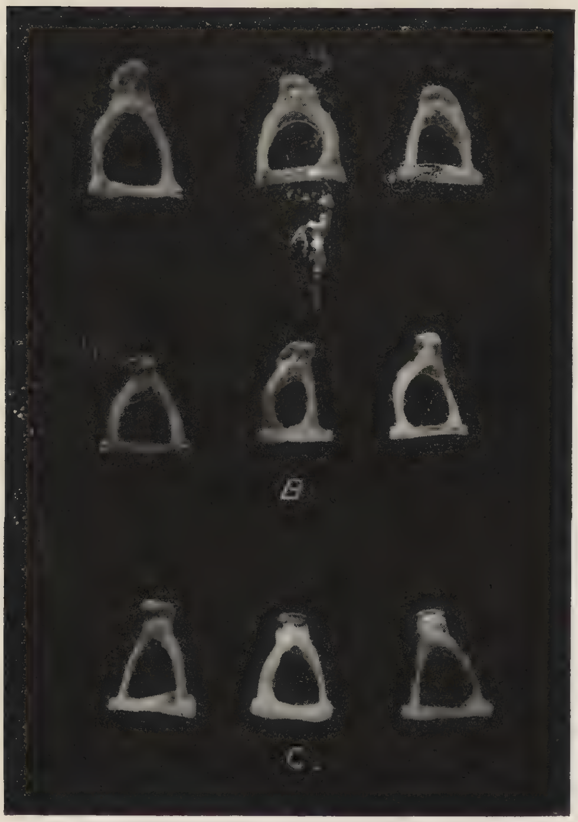

FIG. 4. *Stapes.* External view of the stapes, X4, illustrating:

(a) Illustrates variation in total length of the stapes and of the neck, and the manner of attachment of the head to the arches formed by the crura.

(b) Illustrates the different sizes and forms of the opening between the crura and differences in the size of the individual bones, as well as variation in their shape.

The total width of the stapes measured across the crura varies more than the width of the opening for the calibre of each crus is subject to considerable variation, the anterior usually being narrower than the posterior, as shown in Fig. 4.

The length (AC Fig. 3) of the head and neck of the stapes as measured from the lowest part of the arch formed by the junction of the inner edges of the anterior and posterior crura, to the articular surface of the head varies as 1 to 2:5. This difference in length of the head is due to the variation in the presence of the neck as the head sometimes is sessile and at other times has a decided neck. Variations in these measurements are due also to a shelf of bone formed by the junction of the edges of the crura which sometimes project downwards a whole millimeter.

Although the observations of Urbantschitsch of the shape and external variations of the ossicles were confirmed by my own, as a rule, some things may be added.

Malleus

Variations in form and size of the malleus are shown in figure 5. The two mallei *A* show differences in the medio-lateral diameter of the head; the two *B* variations in the angle between the head and neck and the manubrium, and the three *C* illustrate differences in the length of the short process and in the angle made by it and the manubrium and the head and neck.

The processus brevis which runs out into a well-defined point in 53 out of 82 specimens is more or less rounded in 19 cases and ends in a small crater-like pit in 10 cases. It forms a concavity looking laterally with the lateral edge of the handle in 61 cases, a convexity in just one instance and a straight line in 20 instances.

The manubrium had a lateral concavity at the lower end in 40 out of 82 cases, a lateral convexity in one and extended straight down in 20 preparations. The end of the manubrium was rounded abruptly as though broken in one bone, it ended in a small rounded elongated knob in 7 cases; in a small rounded, more or less pointed termination in 15; and was flattened medio-laterally in 58 cases.

The distance from the lower end of the handle to the periphery of the tympanic membrance could not be determined in my series but Urbantschitsch gave the following figures:

Distance:	mm. mm.	mm.
from point to anterior edge of membrane	2.6 to 4.0	Av. 3.4
" " " posterior " " "	4.2 " 5.6	" 4.6
" " " lower " " "	2.6 " 4.2	" 3.5

Incus

A millimeter or two from its lower end the posterior process of the incus shows a medial sulcus or even an incision shown in ossicles D,F and E Fig. 6. This extends from below, laterally and upward and was present in 36 bones. No sign of an incision or of a dimple or foveola was present in 28 bones but four showed a decided incision on the medial

Fig. 5. A. Anterior view of two left mallei showing the difference in the medio-lateral diameter of the head (X4).
B. Variations in the angles made by the long axis of the manubrium with the long axis of the head and neck in the same. X4.
C. External view of 3 mallei showing differences in the length of the short process and of the angles made by it with the long axis of manubrium and the head and neck. X4.

side of the process near its lower end. The exact significance of this I am not aware of and strangely enough the text-and hand-books do not mention it. Investigators who mentioned it offered no explanation.

The posterior process showed a rounded end in 17 and a pointed one in 70 instances (See figure 5). The anterior process was bent so as to show a concavity in a lateral direction in 18 bones and a concavity

Fig. 6. *Incus.* External view of the incus, x4, illustrating:

(a) The external angles made by the two processes of the incus, the pitting on the medial side with extensive pitting on the anterior process of the middle specimen and a prominent nipple-like projection on the medial surface of the latter.

(b) The lateral surfaces of the two inci showing differences in the angles made by the two processes and a deep incision on the inferior edge of the posterior process of one of them.

(c) Medial view illustrating the varying shape, thickness and length of the anterior and posterior process of the incus.

towards the front in 70 instances. These two characteristics were sometimes combined. The process showed a concavity medially in one instance, and a lateral concavo-convex form in 43 preparations.

The body of the incus usually contains one or more well-defined little pits that may be located on either side near the articular surface. It may be that these occur more frequently in the older specimens where bone resorption is proceeding more rapidly. Two or more pits (See A, B, C Fig. 6) were found on the medial side in 36 cases and on the lateral in 13 specimens. Practically all inci show a small, more or less well-defined, little pit on the lateral side of the body. This pit (See D, E Fig. 6) is usually rather close to the articular surface on the posterior process but may be located almost midway between the two processes. It may serve in the capacity of a nutrient foramen to the incus. The anterior process was pitted much more frequently than the posterior.

A nipple-like protrusion (See B Fig. 6) was present on the medial side in 4 cases only. In two preparations there were rather prominent masses of bone protruding above the surrounding surface. There was a decided hollowing out on the medial side in 30 cases with a pit in the bottom of the hollow in the majority of instances.

A set of ossicles from a fullterm fetus showed very little variation in form from that in the adult except that they were larger than some adult bones. This agrees with the statement of Allen 1884, that "The ossicles are always as large in the newborn infant as in the adult and in some cases larger." The following table gives the measurements obtained on these fetal bones:

Measurements of the Auditory Ossicles From a Fullterm Fetus

Malleus	*Right*	*Left*
1. Length of malleus	8.39 mm.	8.39 mm.
2. Length of manubrium from the tip of the short process	5.32 mm.	5.25 mm.
3. Length of manubrium from the base of the short process	4.2 mm.	4.6 mm.
4. Length of the head and neck from tip of the short process	4.45 mm.	4.45 mm.
5. Length of the long process		
6. Length of the manubrium from base of long process	5.0 mm.	4.75 mm.
7. Length of the head and neck from base of long process	3.25 mm.	3.25 mm.
8. Length of the short process	3.0 mm.	2.75 mm.
9. Medio-lateral diameter of head of the malleus	2.31 mm.	2.28 mm.
10. Dorso ventral diameter of head of malleus	1.62 mm.	1.59 mm.
11. Torsion of malleus	41°	33°
12. Angle between the head and neck and manubrium	136°	141°

13. Angle between the short process and manubrium	130°	130°
14. Angle between the short process and the head and neck	92°	86°
Incus	*Right*	*Left*
1. Angle 1. Internal angle made by the two processes	72°	74°
2. Angle 2. External angle included between the two processes	91°	93°
3. Distance between the tips of the two processes	6 mm.	5.6 mm.
4. Length of the posterior process	5.04 mm.	5.04 mm.
5. Length of the anterior process	4.56 mm.	4.49 mm.
6. Medio-lateral diameter of the body	1.695 "	1.7 mm.
7. Superior-inferior diameter of the body	3.63 mm.	3.48 mm.
Stapes		
1. Length of base	——	——
2. Width of base	3.20 mm.	3.25 mm.
3. Total length of stapes	3.03 mm.	3.78 mm.
4. Length of head	2.35 mm.	3.1 mm.
5. Height of opening	4.0 mm.	4.1 mm.
6. Width of opening	4.25 mm.	4.1 mm.
7. Width across Crura	5.9 mm.	5.85 mm.

SUMMARY OF MEASUREMENTS

Malleus	*Average*	
	43 Right Bones	*47 Left Bones*
1. Length of short process in millimeters	1.14 mm.	1.20 mm.
2. Length of long process	.68 mm.	.58 mm.
3. Weight in milligrams, 44 bones. No's 19-62	25.0	
4. Medio-lateral diameter of head	2.6 mm.	2.50 mm.
5. Dorso-ventral diameter of head	1.9 mm.	1.9 mm.
6. Length of malleus—tip of head to end of manubrium	8.1 mm.	8.2 mm.
7. Torsion between head, neck and manubrium	38.5°	37.4°
8. Length from tip of short process to end of handle	4.9 mm.	4.9 mm.
9. Length from base of long process to end of handle	4.6 mm.	4.5 mm.
10. Length from tip of short process to tip of head	4.6 mm.	4.5 mm.
11. Length from base of long process to tip of head	3.7 mm.	3.7 mm.
12. Length from inner end of short process to end of manubrium	4.6 mm.	4.6 mm.
13. Angle between head, neck and manubrium	129.3°	129.7°
14. Angle between short process and manubrium	123.9°	124.1°
15. Angle between short process, head and neck	94.7°	97.6°
Incus	*41 Right Inci*	*48 Left Inci*
1. Internal angle made by two processes of incus	76.5°	71.3°
2. External angle made by two processes of incus	99.2°	95°
3. Distance between tips of two processes	6.2 mm.	6.1 mm.
4. Length of posterior process in mm.	5.2 mm.	5.2 mm.
5. Length of anterior process in millimeters	4.7 mm.	4.7 mm.
6. Weight (63 bones)	27.8 mgs.	

Stapes	*11 Right Bones*	*20 Left Bones*
1. Length of base of stapes	2.9 mm.	2.9 mm.
2. Total height of stapes	3.5 mm.	3.4 mm.

As shown in the accompanying table 2, the average actual measurements of the malleus vary only slightly when comparing the right bones with the left, the average variation being approximately 1.7%. The greatest difference seems to exist in the measurements of the bony masses for the antero-posterior diameter of the head of the malleus varies 2.1%.

TABLE 2

	Percentage of variation between the smallest and greatest measurements of the ossicles		Percentage of variation between the smallest and greatest measurements of the ossicles and the average of the series				Percentage of variation between the average measurements of right and left bones	
	MALLEUS							
	Right	*Left*	*Right*		*Left*		*Right*	*Left*
			Smallest	*Greatest*	*Smallest*	*Greatest*		
Total length...	14.1%	16.9%	9.2%	5.64%	10.03%	8.32%		24%
Angle made by the Head and Neck with the manubrium....	48.2	58.6	29.79	35.2	40.35	44.11	1.05%	
Medio-lateral diameter of the head..........	24.28	23.23	13.33	19.6	11.6	15.02	1.09	
Antero-posterior diameter of the head..........	38.9	27.	17.29	35.1	12.8	19.05		2.11
Length of manubrium from the tip of the short process...	26.09	25.86	14.05	17.1	12.2	18.4	.2	
Length of head and neck from the tip of the short process...	30.7	34.28	17.5	27.18	23.16	16.9	1.53	
Angle made by short process (long axis) with the manubrium.	59.3	60.7	37.6	53.2	39.8	54.7		3.2
Angle made by short process (long axis) with Head and Neck.	30.4	30.1	15.49	21.4	17	18.9		3.

(Table 2—Continued)

	Percentage of variation between the smallest and greatest measurements of the ossicles		Percentage of variation between the smallest and greatest measurements of the ossicles and the average of the series				Percentage of variation between the average measurements of right and left bones	
	Incus							
	Right	*Left*	*Right*		*Left*		*Right*	*Left*
			Smallest	*Greatest*	*Smallest*	*Greatest*		
Length of posterior process...	21.9%	26.56%	14.4%	9.63%	12.37%	19.3%	.38%	
Length of anterior process...	19.5	15.43	10.8	10.8	8.9	8.17	.21	
Medio-lateral thickness of body	28.	38.9	14.1	21.9	21.1	29.1	2.9	
Caudo-cephalic thickness of body..........	12.7	21.1	9.04	4.25	10.46	13.4	3.4	
Internal angle made by the two processes......	29.5	23.3	20.2	13.02	13.4	12.7	6.8	
External angle between the two processes......	29.5	27.8	13.2	23.	18.3	11.1	4.2	
	Stapes							
Total length...	17.2	32.2	11.2	7.2	12.4	29.	.86	
Width of opening between crura..........	38.4	33.3	28.2	18.1	17.6	23.5		2.8
Width across crura..........	31.5	25.	16.	16.7	9.8	20.1	4.5	

The average measurement of the medio-lateral and caudo-cephalic thicknesses of the body of the incus varies 2.9% and 3.4% respectively. The width across the crura of the stapes has the greatest variation, the right bone being 4.5% wider than the left on an average, and the width of the opening between the crura varying up to 2.8%.

The percentage differences are based upon the larger of the two measurements.

The last two measurements are dependent to a large extent upon the difference in the angle enclosed between the two crura and in all the measurements the angles made by the various bony processes appears subject to greater variations than the masses of the bones themselves. This is shown in comparing the angles made by the long axis of the head and neck with the long axis of the manubrium in the right and left

mallei. The right side shows an average angle of 1 per cent greater than the left, this being the least variation in the angles in any bone. In the inci, the internal angle on the right side is 6.8 per cent larger than that on the left.

As shown in Table 2 these variations in size of the ossicles are less than those found in some other bones of the body, for Holtby 1917–18 found variations in the length of the femur in males equal to approximately 28 per cent. The diameter of the head of the femur in males varied 18.6 per cent on the right and 27.2 per cent on the left.

STRUCTURE OF THE OSSICLES

Two sets of ossicles were examined microscopically and my observations upon these largely confirm those made by Donalies 1897. There appears to be no orderly arranged compacta and spongiosa in the malleus such as exists in long bones, but there is a general structural resemblance to these. The malleus possesses an outer layer of more or less compact bone of varying thickness and a second layer somewhat less compact. Both layers are pierced at frequent intervals by canals of varying diameter. Some of these canals are surrounded by Haversian lamellae but others are without a definite lamellar arrangement and connect with or run together, to form larger canals which open into the large central cavities or which end upon the surface of the bones in small pit-like depressions. Only traces of spongiosa are to be found in the form of small bony trabeculae and spicules which run across or project into the meduallary cavities.

Malleus

The manubrium, the short process, and the head and neck of the malleus all possess medullary cavities. These cavities are connected and follow somewhat the external shape of the bone but each cavity is broken up more or less by the reticular-like walls and spicules of spongiosa which give the cavities in some cases the appearance of a honeycomb with many broken down cells opening into each other.

Incus

The incus resembles the malleus in its internal structure, except, perhaps that it possesses a larger amount of the more compact bone. This accounts for its greater weight. The posterior and anterior processes contain cavities. The anterior process has cavities that can be compared to the medullary cavity of long bones more readily than can the more or less detached and smaller cavities found in the posterior process. The larger cavities in the processes connect directly with the

open spaces in the center of the body of the incus, while the smaller Haversian systems found in the more solid bone, run together and eventually join those systems also. Donalies estimated that the total area of the cànals and cavities in a cross section of the body of the incus equals one-third of the total area of the section.

The interior of the lower end of the anterior process and the neck and body of the lenticular process appear to resemble spongiosa much more than the larger part of the vertical process. The lenticular process, in fact, has a very large cavity in the center.

Stapes

The stapes is not much more than a shell, but in section nevertheless resembles compacta for the Haversian systems are smaller and do not join to form any large cavities. There is no space that can be called a meduallary cavity.

The neck, head and foot plate, as well as the crura, are all hollow. Each crus and the footplace has the shape, usually of a rounded trough, opening inward. The neck in some cases is hollow and opens into the hollow head so that the latter is nothing but a shell surrounding an air space. In other cases the neck is more or less solid but the head and neck have been hollowed out, usually from the superior surface. Hence the mass of bone actually present is about the same. The articular surface of the head in these cases extends out over the hollowed-out area as though the walls and supports on that side had been pushed posteriorly leaving the roof still intact.

The anterior and posterior end of the footplate seem to be the heaviest part of the stapes as though the fusion of the crura with the place had caused a mass of bone to be deposited. These ends are hollowed out somewhat by the continuation of the trough in the crura and plate but the hollowing out process, does not approximate so closely the external shape as is the case with the rest of the stapes.

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A CONTRIBUTION TO THE MORPHOLOGY OF THE APERTURA PIRIFORMIS

CHARLOTTE D. GOWER[1]

The variations found in the structure of the lower border of the piriform aperture have been the subject of considerable anthropological study. In 1850 it was observed by Meil that Caucasian skulls have at the lower border of the apertura piriformis a sharp ridge, which is lacking in African skulls as well as in those of apes and lower mammals. Somewhat later Hamy associated this sharp border with orthognathism, and the lack of it with the prognathous condition. Topinard emphasized it as a racial difference, claiming that the nasal aperture with a rounded lower border is typical of non-European races. In the present study no attempt is made to discuss the racial significance of the structures described, but emphasis is laid on the morphological relationships.

The first detailed description of any of the varied forms of the apertura piriformis was given by Zuckerkandl in his account of the skulls of the Novara collection (1875). He described what he termed *fossae prenasales*—bow-shaped furrows of varying dimensions, lying on either side of the nasal spine, and constituting a border region between the floor of the nose and the face. Because these fossae occur among races commonly regarded as primitive, and are absent among Europeans, several writers have judged their possession an atavistic character. Objections were raised to this theory, and the ensuing controversy greatly furthered the study of the lower border of the nasal opening. As a result the forms of this part of the bony nose were finally resolved into four types by Hovorka (1893), as follows:

1. The *forma anthropina* [Mingazzini—1891], consisting of a single sharp ridge forming a *margo limitans*, or definitive boundary between nose and face.

2. *Fossa prenasalis*, where the *margo limitans* consists of two ridges with an intervening space.

3. The *forma infantilis*, with the *margo limitans* incomplete. The crests are in general not sharp but rounding, and there may be some suggestion of a fossa prenasalis. The name is derived from the prevalence of this form among children up to the age of nine or thereabouts, though it also occurs in adults.

[1] Contribution from the Department of Zoology, Smith College, No. 103.

4. *Sulcus prenasalis,* or "*Affenrinne,*" with an absence of any transverse ridges to divide the nose from the face. As the German name indicates, this form is that found most commonly among apes. Its occurrence in man is agreed to be atavistic.

These four types of Hovorka, as used by Macalister (1898) in a slightly different order, and with the addition of certain adjectives, has been recently taken by Sullivan (1922) as the basis for nasal variations in his work on the percentages of the numerous varieties found in American skulls, and thus becomes of sufficient importance to be mentioned here. Macalister's types [Hovorka's], as employed by Sullivan, are as follows:—

1. *Infantile,* or amblycraspedote
2. *Anthropine,* or oxycraspedote
3. *Praenasal fossae,* or bothrocraspedote
4. *Naso-alveolar sulcus,* or oxygmocraspedote [Hovorka's *sulcus prenasalis* or "Affenrinne."]

The ridges which are involved in the formation of the lower border of the piriform aperture have been variously described and named.

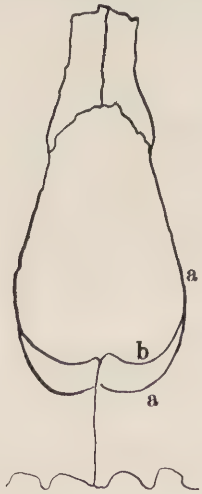


Fig. 1. Ridges at the base of the piriform aperture according to Holl's description (1882).
a = crista maxillaris
b = crista intermaxillaris

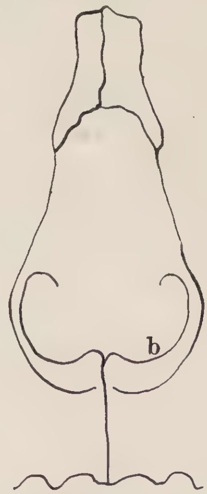


Fig. 2. Ridges at the base of the piriform aperture according to Bonin's description (1912).
a = crista nasalis anterior
b = crista nasalis posterior

Holl (1882) the first to place emphasis on the boundaries of the fossa prenasalis, described the lateral edge of the nasal opening as forking, its

two branches marking the limits of the furrow (Fig. 1). The inner branch, running across the floor of the nose to the nasal spine, he called the crista intermaxillaris—the outer branch, the crista maxillaris, a name which he also applied to the lateral edge before its division. These names were given to indicate relations to bones of the skull; thus the crista intermaxillaris was considered as lying on the intermaxillary (=premaxillary) bone, the crista maxillaris mostly on the maxillary. However, Bonin (1912) has pointed out that the crista maxillaris, as well as the crista intermaxillaris, lies entirely on the premaxillary bone, so that the names given by Holl are without meaning. The two ridges have been variously renamed by different writers, as has a third ridge, the crista naso-dentalis [Zuckerkandl]. This ridge, lying farther back in the nose, was identified as the raised bony roof of the canal for the naso-dental nerve, and marked by the occurrence of small openings along its course. By 1910 so many different terms had been applied to the separate features of the lower border of the nasal aperture that Klaatsch declared that "a confusion of superfluous nomenclature obscured a picture clear and simple in itself."

The most recent work to be done on these ridges was that of Bonin in 1912. Calling the maxillary crest of Holl crista anterior, he took as his posterior crest a ridge running from the nasal spine to the anterior end of the lower turbinal, and identified it with Holl's intermaxillary crest and Zuckerkandl's crista naso-dentalis (Fig. 2). Then, studying a large number of skulls from different races, he classified them according to whether the anterior or posterior crest formed the definitive boundary between nose and face. Races in which the anterior crest forms the *margo limitans* are, according to Bonin: Australians, Tasmanians, Negroes, Bushmen, Lapps, and one type of Malay. In Europeans, Mongolians, and the other Malay type he found the posterior to be the defining crest.

In a number of skulls of the Smith College collection, the structure of the piriform aperture gave evidence of three ridges rather than two. Moreover, even in skulls where two ridges might form a satisfactory basis for description, a clearer understanding of the morphological relationships is obtained by the assumption of a third ridge or crest. These crests are the following, enumerating from without in:

1. The extension of the sharp lateral wall (=crista maxillaris [Holl], =crista prenasalis [Klaatsch], =crista nasalis anterior [Bonin]). The name given by Bonin has the advantage of clearness and simplicity, but at the same time cannot be regarded as wholly satisfactory, since

this crest occasionally fuses with what he termed the posterior crest, rendering nomenclature based on their mutual relationship somewhat misleading. The surest basis for naming these ridges appears to be that of origin, and for this reason, the ridge may be termed *crista lateralis*. (*a* in Figs. 3–6.)

2. A ridge which branches sharply off from the nasal spine, and runs in a postero-lateral direction across the floor of the nose. From its origin, it may be called the *crista spinalis*. The angle it forms with the median palatal (here = interpremaxillary) suture varies in size from approximately ninety degrees to an angle so small that the crest may be considered absent. Since the spinal crest is always involved in the formation of the margo limitans, its absence means the existence of a sulcus prenasalis. Moreover, because such a condition is generally thought to be atavistic or pithecoid, the crista spinalis may be regarded as a distinctively human character. (*b* in Figs. 3–6.)

3. A ridge which, seldom sharp, arises near the anterior end of the inferior turbinal, and runs downward, sometimes disappearing completely or merging with one of the other ridges, and at other times more or less distinctly traceable sa far as the median line. Often it can be seen at its extremities, i.e. near the turbinal and near the median palatal suture, while at the center the bone seems perfectly flat. This ridge, more often than either of the others, shows the indications of a canal, and very likely may be the crista naso-dentalis of Zuckerkandl. However, the impossibility of perceiving traces of a canal in all skulls, and the occurrence of cases when this ridge and the canal do not coincide, makes the existence of any definite relation between the two difficult of demonstration. On the basis of origin, this third ridge may be named *crista turbinalis*. (*c* in Figs. 3–6).

The names *crista lateralis*, *crista spinalis*, and *crista turbinalis* are given, despite the multiplicity of names already in existence (see table of nomenclature), in hopes that by the use of descriptive terms such as these there can be no confusion concerning to which crests they apply. The origins alone of these ridges may be considered constant, while their relative positions, length, and form vary considerably from individual to individual.

These ridges occur in all manner of varying relations to each other, from the infantile form, with all three discernible as separate crests, to the anthropine form where the single sharp ridge has at once the characteristics of the lateral and spinal crests, while the crista turbinalis, beginning but a few millimeters posterior to the margo limitans, slants

forward and unites with it, giving complete fusion of the three ridges. Thus, this form showing a single boundary is apparently the simplest and actually the most complex of all the forms. The many different possibilities of development and fusion of these three ridges are responsible for the extreme variability in the appearance of the lower border of the nasal opening.

The most common fusion is that of the spinal and turbinal crests, producing the single ridge which Bonin called "crista nasalis posterior,"

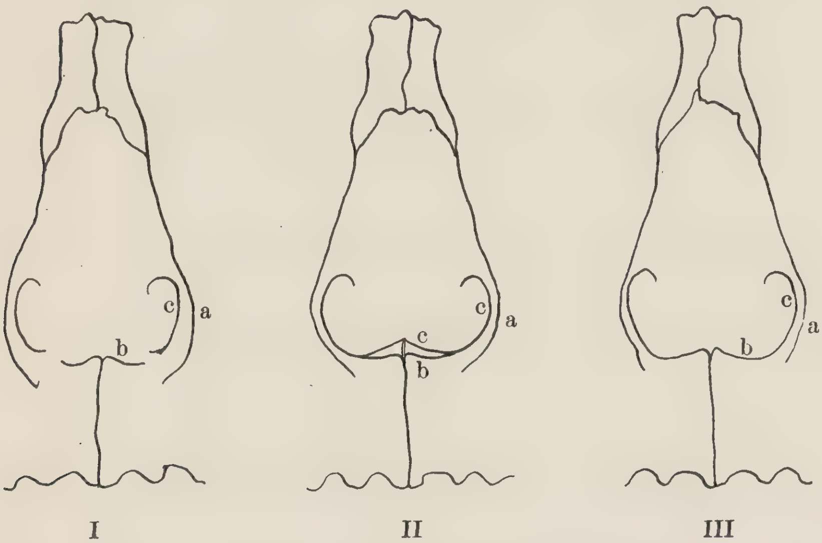


FIG. 3. Possibilities of development of the spinal and turbinal crests.
I. No fusion: b and c separate.
II. Partial fusion of b and c.
III. Complete fusion of b and c, resulting in a single ridge.
a = crista lateralis
b = crista spinalis
c = crista turbinalis

extending from the nasal spine to the anterior end of the lower turbinal. This fusion may be complete (Fig. 3, III), or only partial (Fig. 3, II), so that Bonin's posterior crest would seem to divide into two parts as it approaches the spinal crest. Between the two branches there lies a triangular depression, which should be called the fossa intranasalis, since it is precisely the structure to which Zuckerkandl applied that term, although its boundary ridges have been renamed. This term may

be generally applied to any space which lies between the turbinal and spinal crests.

In cases of the type described in the preceding paragraph, when fusion occurs between the crista turbinalis and the crista spinalis, the lateral crest takes various forms. In many instances it disappears, running down on the surface of the premaxillary for a few millimeters only, and then flattening out (Fig. 4, I). On the other hand it may

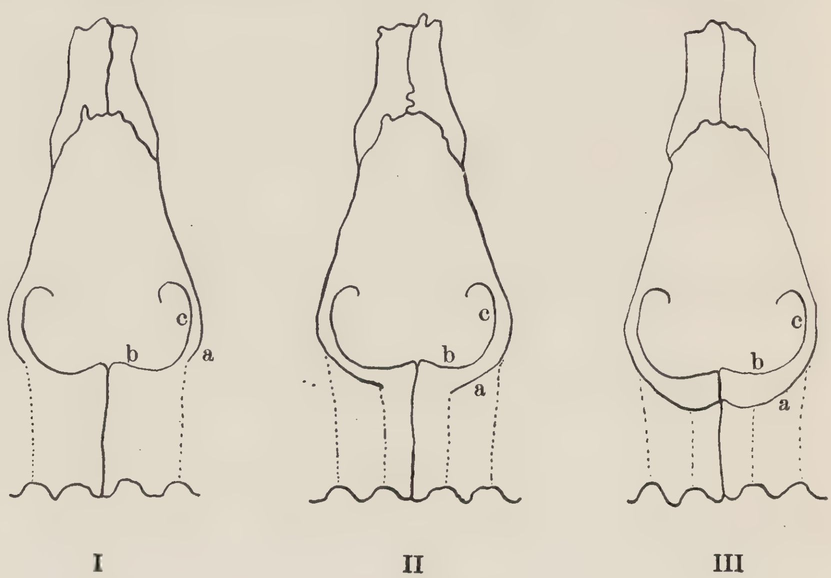


FIG. 4. Possibilities of development of the lateral crest. (The dotted lines indicate branches which may extend down to the teeth.)

I. Lateral crests but slightly developed.
II. Lateral crests interrupted by roots of the incisor teeth.
III. Lateral crests meeting in the median line. Formation of a fossa prenasalis.

a = crista lateralis
b = crista spinalis
c = crista turbinalis

continue as a well-defined ridge curving inward and extending even as far as the intermaxillary suture. When the roots of the incisor teeth are especially prominent and long, they may extend up into this ridge, interrupting its course, so that it seems to turn abruptly and run down to the tooth (Fig. 4, II). At other times the crista lateralis seems to divide, sending a branch to the roots of each incisor tooth. Whether

this branching occurs or not seems to be dependent on the extent and prominence of the roots of the teeth.

When the crista lateralis extends medially, even if not as far as the mid-line, there exists between it and the spinal crest a depression, the fossa prenasalis (Fig. 4, III). This varies in size and depth from a mere furrow to a hollow of appreciable dimensions. Dwight (1892) records for this fossa such measurements as the following: sagittal length, 18 mm.; transverse length, 20 mm.; depth, 8 mm.; as illustrating an extreme case.

The above forms of the lateral crest may also occur when the other two ridges do not fuse but remain entirely separate. Under such conditions, the classification of the type as "infantile" or "fossa prenasalis" depends on the amount of curvature of the lateral crest and on the development of the spinal crest. The angle between the median palatal suture and the crista spinalis is of great importance in the formation of a prenasal fossa, since, if it is very small, the two crests will never appear to run parallel to each other, however far medially the crista lateralis extends (Fig. 5), and the ridges must be parallel to outline the fossa. Thus, the existence of the fossa prenasalis depends on the spinal as well as on the lateral crest.

Besides fusing with the turbinal crest, the crista spinalis may also unite with the lateral crest to form a single border about the piriform aperture. This form can be distinguished from that in which all three ridges unite, only by the appearance of the inconspicuous turbinal crest within the nasal cavity. From outward appearances both forms would be called anthropine, though morphologically distinct types. This lack of parallelism between the accepted anthropological classification, and that which must naturally result when the morphology of the three ridges is used as a basis, is seen in the following table:

Anthropological Types	Morphological Types
Sulcus prenasalis	No spinal ridge
Forma infantilis	Three ridges separate
Fossa prenasalis	Three ridges separate Spino-turbinal fusion
Forma anthropina	Spino-lateral fusion All three ridges fused

It may be seen that the existence of three separate ridges may give the appearance of either the infantile form or that of fossae prenasales, while the latter type also occurs when there is fusion of the spinal and

turbinal crests. Likewise no anthropological name has been given to the type shown in Figure 3, I, where the spinal and turbinal crests fuse, but where the crista lateralis is only slightly developed—a type not at all rare. It has probably hitherto been classed with the anthropine form, if the spinal crest, leaving the median line almost at right angles, runs close to the crista lateralis in fusing with the turbinal crest, which in this case would arise far forward (Fig. 6, I). If, on the

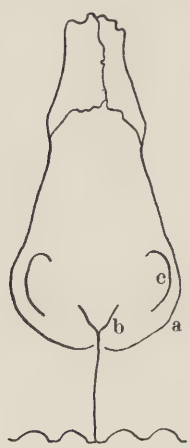
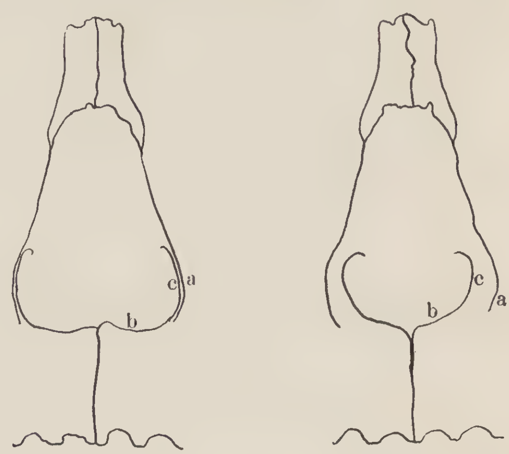


Fig. 5. Condition showing a small angle between the crista spinalis and the median palatal suture; no fossa prenasalis being possible.
a = crista lateralis
b = crista spinalis
c = crista turbinalis



I II

Fig. 6. Condition showing spino-turbinal fusion.
I. a and c very close together.
II. a and c far apart.
a = crista lateralis
b = crista spinalis
c = crista turbinalis

other hand, the crista spinalis runs diagonally back to meet the turbinal crest lying somewhat back in the nasal cavity, the appearance would be that of the infantile form (Fig. 6 II). Accordingly, the anthropological classification, based solely on the appearance of the lower border of the nasal aperture, though convenient, is found to have no significance as regarding the morphology of the region.

It may be that the morphological types will be found to have a greater significance for the study of racial differences than do the anthropological types. At any rate they seem to show more clearly, through different degrees of fusion, separate stages in development. This fu-

sion of the three ridges may be in part due to the decrease in size of the dental arch, and the consequent reduction of the entire region of the upper lip and lower nasal border; but it is improbable that this affords an adequate explanation for all the changes observed.

TO SUMMARIZE: three ridges enter into the formation of the lower border of the piriform aperture. They are, (1) the *crista lateralis*, arising from the lateral border of the opening; (2) the *crista spinalis*, originating from the nasal spine; and (3) the *crista turbinalis*, having its origin near the anterior end of the lower turbinal bone. Of these, the crista spinalis is found only on human skulls, while the other two crests appear also on those of apes and lower mammals. It is this crista spinalis which, by its direction and amount of development, determines what fusion, if any, occurs, and thus is responsible to a great extent for the appearance of the entire region.

In concluding, I wish to thank Dr. Harris H. Wilder for his aid and encouragement during the preparation of this paper, as well as for the use of the Smith College collection of skulls. To the Wistar Institute I am greatly indebted for the loan of a number of crania of different races which were used in this study.

[There has just appeared in the Mitteilungen der Anthropologischen Gesellschaft zu Wien, 1 December, 1921, an article by W. Aigner, describing a skull with a typical *fossa praenasilis* upon the left side, while the right side shows a single, clear-cut ridge, probably the *crista spinalis*. The skull is that of a male Serbian, 37 years old. H. H. W.]

TABLE OF NOMENCLATURE

HOLL	ZUCKERKANDL	KLAATSCH	BONIN	GOWER
Crista maxillaris	Crista maxillaris	Crista prenasalis	Cr. nasalis anterior	Crista lateralis
Cr. intermaxillaris	Cr. intermaxillaris	Margo infranasalis	Cr. nasalis posterior	Crista spinalis
....	Cr. nasodentalis	.....		Crista turbinalis

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RELATION OF EPIPHYSEAL LENGTH TO BONE LENGTH

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Although there is abundant literature describing the internal structure of the long bones, the relation of the height of the epiphysis to bone length has not been investigated it seems. The data upon which this paper is based were obtained from the examination of adult bones, mostly Caucasian, of varying age. They were of the usual type which is found in the dissecting room and had been fairly well cleaned. The interior of the bone was exposed by a single sagittal cut, extending full length and made with the aid of a band saw. The measurements were taken with a large caliper graduated in millimeters.

Humerus

Only the proximal epiphysis could be recognized with any great amount of frequency in this bone. The distance from the greatest prominence of the head to the lateral trochlear surface was taken as the length of the bone. The distance between the former point and the epiphyseal line was recorded as the height of the proximal epiphysis. Of the 100 bones examined, the height of this epiphysis could be determined on 84. Of this number a few were cleansed of grease by continued boiling. The remaining discarded bones were too greasy or slightly damaged but it is questionable whether any of them would have failed to show the epiphyseal line if undamaged and thoroughly clean.

The measurements recorded in Table 1 showed a variation of 82 mm. in the length of the humeri and a fluctuation of 9 mm. in the height of the epiphyses. The average length of 40 bones of the left side in which the epiphysis could be measured was 32.1 cm. and that of the epiphysis 17.6 mm., or 5.5 per cent of the bone length. The 44 bones from the right side had an average length of 32.5 cm. and the epiphyses averaged 18.4 mm. in height, or 5.7 per cent of the bone length. It is significant that while the average lengths of the bones from the right and left side showed a difference of slightly more than 4 mm. the difference between the average epiphyseal lengths of these bones was but 0.8 mm. Since these differences are equivalent to 1.2 per cent of the total average length of the right humerus but only to 0.4 per cent of the average

TABLE 1

MEASUREMENTS ON 44 RIGHT HUMERI AND 40 LEFT

Length of bone in cm.	Height of Epiphysis in cm.	Percentage of total bone length formed by the epiphysis	Length of bone in cm.	Height of Epiphysis in cm.	Percentage of total bone length formed by the epiphysis
Right:			*Left:*		
28.6	1.6	5.8	28.3	1.5	5.3
28.7	1.6	5.7	28.7	1.6	5.6
29.5	1.6	5.4	29.1	1.5	5.1
30.0	1.7	5.7	29.2	1.5	5.1
30.0	1.7	5.8	29.7	1.8	6.0
30.0	1.9	6.5	30.2	1.7	5.6
30.3	2.0	6.6	30.6	1.7	5.5
30.5	1.7	5.4	30.8	1.7	5.4
30.9	1.8	5.9	30.9	1.6	5.3
30.9	1.9	6.0	30.9	1.9	6.1
31.1	1.8	5.8	31.5	1.7	5.4
31.1	1.8	5.9	31.5	2.0	6.2
31.2	1.9	5.9	31.5	2.1	6.8
31.3	1.7	5.6	31.7	1.7	5.4
31.4	1.9	5.7	31.8	1.7	5.3
31.7	1.5	4.7	31.8	1.9	6.0
32.4	1.6	5.1	31.8	2.2	7.1
32.4	1.9	5.9	31.9	1.6	5.2
32.4	1.9	5.9	32.2	1.7	5.2
32.4	1.6	5.0	32.2	1.5	4.6
32.5	1.7	5.1	32.4	2.1	6.3
32.5	2.0	6.2	32.4	1.7	5.4
32.7	1.7	5.2	32.5	2.0	6.0
32.8	2.2	6.9	32.6	1.3	4.1
32.9	1.6	4.9	32.7	1.9	5.8
32.9	1.9	5.9	32.7	1.6	4.9
33.0	1.7	5.3	32.9	1.8	5.3
33.0	1.8	5.5	32.9	1.9	5.6
33.2	2.2	6.8	33.0	2.0	5.9
33.2	1.8	5.4	33.0	1.7	5.0
33.4	2.1	6.2	33.0	1.8	5.4
33.6	1.8	5.4	33.1	1.8	5.4
33.6	2.0	5.8	33.1	1.9	5.7
33.7	1.8	5.5	33.4	1.6	4.9
33.9	1.8	5.4	33.4	1.6	4.9
33.9	1.9	5.7	33.9	1.6	4.8
34.0	2.1	6.3	34.1	1.9	5.6
34.4	1.9	5.5	34.1	1.9	5.6
34.5	1.8	5.2	35.2	1.6	4.5
35.3	1.7	5.0	35.6	2.0	5.6
35.3	1.9	5.5			
35.7	1.8	5.2			
35.8	2.1	5.9			
36.5	1.9	5.2			

height of the right epiphysis, they suggest that the relation existing between bone length and epiphyseal height is not a direct one. This fact becomes more evident upon consulting the accompanying correlation table.

The lack of correlation between the length of the humerus and that of the proximal epiphysis is evident in table 2. In the few humeri ranging from 28.0 to 30.0 cm. there is but little if any correlation between the height of the epiphysis and the total length of the bone, and for those of

TABLE 2

Length of Humeri in cm.	HEIGHT OF PROXIMAL EPIPHYSES in cm.									
	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2
28.1–29			3	3						
29.1–30				1	3	1	1	1		
30.1–31				3	2	5	2			
31.1–32			2	3	5		4	1	1	1
32.1–33	1			6	3	5	5	2		2
33.1–34				1		4	4		1	
34.1–35				1	1	1	1			
35.1–36						1		1	1	
36.1–37							1			

lengths lying between 30.0 and 33.5 cm. such a relation is entirely absent. A humerus only 33.0 cm. in length may have an epiphysis 13 or 22 mm. in height. Bones exceeding 33.5 cm. are scattered quite far in the table and the longest bone examined, one 36.5 cm. in length, showed an epiphysis hardly surpassing the average height.

The absence of a definite relationship between bone length and epiphyseal height is further emphasized in Fig. 1. The slant of the broken line in this figure indicates the increase in lengths of the humeri, the length of which is given below, and the slightly ascending continuous line the increasing height of epiphyses from the respective bones. Although the ascent of the former is quite marked, that of the latter is extremely slight. That is, the two are not in any sense parallel as they

should be if a constant relation existed between bone length and epiphyseal height.

TIBIA

Of 108 bones examined, the height of the proximal epiphysis could be obtained in 58 and that of the distal epiphysis in 55. In 32 bones not enough of the epiphyseal line was evident to allow an accurate measurement. Many of these bones were too greasy and others had been

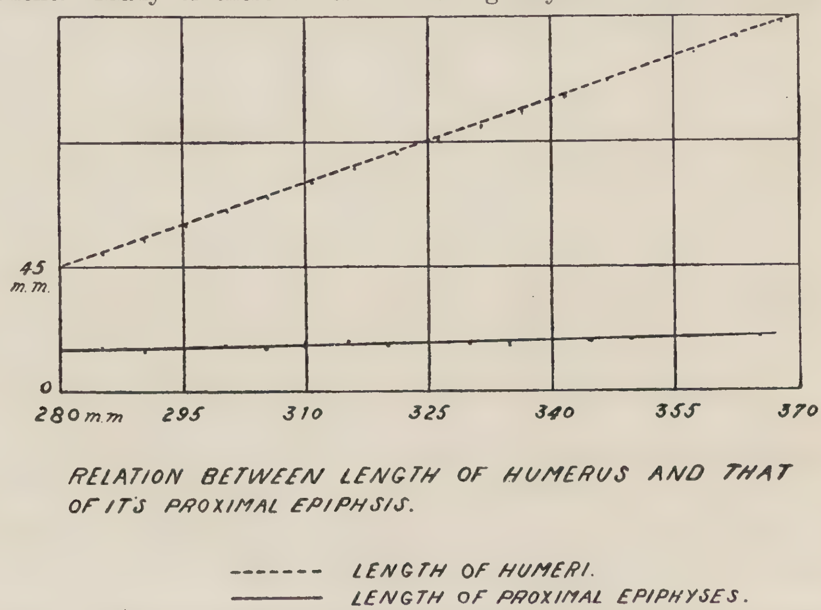

FIG. 1. Graphs showing the relationship between the length of the humerus and that of its proximal epiphysis.

damaged. As with the humeri, an effort was made to cleanse the greasy bones further and this made possible the measurement of one or both epiphyses on 75 per cent of them.

The length taken of the tibia was the greatest length, or the distance between the most prominent point of the intercondyloid eminence and the tip of the medial malleolus. The results are set forth in table 3.

The height of the proximal epiphyses was measured in sagittal sections of the bone, as the distance between the mid-point of the epiphyseal line and a point just posterior to the intercondyloid eminence.

Twenty-nine bones from the right side averaged 37.3 cm. in length with epiphyses averaging 12 mm. high. An equal number from the left

TABLE 3

MEASUREMENTS OF 38 RIGHT AND 37 LEFT TIBIAE

Length of bone in cm.	Height of proximal epiphysis in cm.	Percent of height of proximal epiphysis in bone length.	Height of distal epiphysis in cm.	Percent of height of distal epiphysis in bone length	Length of bone in cm.	Height of proximal epiphysis in cm.	Percent of height of proximal epiphysis in bone length	Height of distal epiphysis in cm.	Percent of height of distal epiphysis in bone length
Right:					*Left:*				
31.5	1.2	3.8			33.3	1.2	3.6	.8	2.5
32.8			.7	2.2	34.1	1.1	3.3		
33.1	1.2	3.6			34.2	1.2	3.5	.9	2.5
33.7	1.0	3.1	.9	2.8	34.5	1.0	2.9		
33.9			.9	2.5	34.7	1.1	3.2		
34.3	1.1	3.2	.7	2.1	34.9			.9	2.6
34.9	1.1	3.2			35.8	1.2	3.3	1.0	2.7
35.2	1.2	3.3			36.2	1.1	3.0	1.0	2.9
35.2	1.2	3.4	.9	2.6	36.3			.8	2.1
35.5			.8	2.1	36.4	1.3	3.6	1.0	2.7
35.8	1.0	2.8			36.4			.7	2.1
35.8	1.1	3.1	.7	2.0	36.5			.9	2.5
35.9	1.3	3.6	.9	2.4	36.7	1.0	2.6		
36.2	1.1	2.9			36.8			.9	2.6
36.4	1.2	3.3	.8	2.3	37.0	1.0	2.6		
36.4			.9	2.5	37.1	1.1	3.0	.9	2.3
37.0	1.1	3.1	.8	2.3	37.2	1.1	3.1	1.0	2.7
37.2	1.2	3.2	.7	1.9	37.3	1.2	3.3		
37.2			.7	2.0	37.3	1.3	3.5		
37.2	1.0	2.8	1.0	2.8	37.4			.7	1.9
37.4	1.2	3.1	.9	2.5	37.9	1.0	2.7	.9	2.3
37.6			.9	2.5	38.0	1.3	3.4	.8	2.1
37.8	1.0	2.6			38.0			.7	1.8
37.9	.9	2.5	.9	2.5	38.1	1.1	3.0		
38.1			.8	2.2	38.2	.9	2.4	.7	1.8
38.3	1.0	2.7	.8	2.0	38.5	1.1	2.8	.8	2.1
38.4	1.5	3.9			38.5			.8	2.0
38.5	1.3	3.4			38.9	1.2	3.2	.9	2.2
39.5	1.4	3.5	.9	2.3	38.9	1.2	3.1	.7	1.9
39.8	1.0	2.4	.8	2.1	39.0	1.3	3.2	.8	2.2
40.0	1.1	2.7	1.0	2.5	39.4	1.3	3.3		
40.2			.9	2.4	39.6	1.0	2.6		
40.2	1.2	3.0	.9	2.2	39.8	.9	2.3	.9	2.3
40.6	1.0	2.6			39.9	1.3	3.1	.9	2.2
41.0	1.4	3.4			40.5	1.0	2.5	7.7	1.8
41.2	1.1	2.7	.8	1.8	40.9	1.4	3.3	1.0	2.4
41.3			.8	2.0	42.0	1.0	2.5	.9	2.3
41.9	1.0	2.5	.8	1.9					

side measured, on an average, 37.65 cm. and showed a mean epiphyseal length of 11.4 mm. That is, the longer bones had the shorter average epiphyses. As shown in Table 3, the tibiae vary 10.53 cm. or 28.2 per cent in length, while the epiphyses show an average difference in height of only 0.6 mm. or 5.2 percent. Although the divergence between the average epiphyseal lengths on the two sides is only o.6 mm., it strangely enough is contra-lateral, the higher epiphyses being on the side of the shortest tibiae. However, since the number of bones from each side

TABLE 4

The Correlation Between the Length of the Tibia and That of its Proximal Epiphysis

Length of Tibia cm.	HEIGHT OF THE PROXIMAL EPIPHYSIS OF TIBIA in mm. 9	10	11	12	13	14	15	Totals
31				1				*1*
32								
33		1		2				*3*
34		1	4	1				*6*
35		1	2	2	1			*6*
36	1	1	1	1	1			*5*
37	2	3	4	2	1			*12*
38	1	1	2	3	2		1	*10*
39	2	1		1	1	1		*6*
40		2	1	1	1			*5*
41		1	1			1		*3*
42		1						*1*
Totals	*6*	*13*	*15*	*14*	7	*2*	*1*	*58*

was so small one cannot be certain that a difference of a little more than half a millimeter in average heights does not lie within the range of error.

The absence of a relation between the height of the proximal epiphysis and the length of the tibia is expressed in table 4. Bones with a length far above the average were found to possess epiphyses both greater and less in height than the average. The average tibial length was 37.48 cm. and the average length of the epiphysis 11.4 mm.

The length of the distal epiphysis was taken as the distance between the mid-point of the distal epiphyseal line and the inferior articular surface, the bones having been cut sagittally as previously described. These epiphyses varied 3.6 mm. in length as compared with a variation of 9.2 cm. in bone length. Of the 55 bones upon which a measurement of the epiphyses was possible, 27 were from the right side. These had an average length of 37.48 cm. and an average epiphyseal length of 8.6 mm.

TABLE 5

The Correlation Between the Length of the Tibia and That of its Distal Epiphysis

Length of Tibia cm.	HEIGHT OF THE DISTAL EPIPHYSES TIBIAE in mm.								
	7	7.5	8	8.5	9	9.5	10	10.5	Totals
32	1								*1*
33				2		1			*3*
34		1		1	1				*3*
35	1	1	1		1	2			*6*
36		2		1	2	1	1	1	*8*
37	3			3	1	2	1	1	*11*
38	3	1	3	3					*10*
39				1	3				*4*
40	1			1	1	1	2		*6*
41		1	1						*2*
42						1			*1*
Totals	*9*	*6*	*5*	*12*	*9*	*8*	*4*	*2*	*55*

The 28 bones from the left side which were not pairs, had an average length of 37.63 cm. The average epiphyseal length was exactly the same as that on the opposite side. The epiphyseal height varied 41.8 percent,

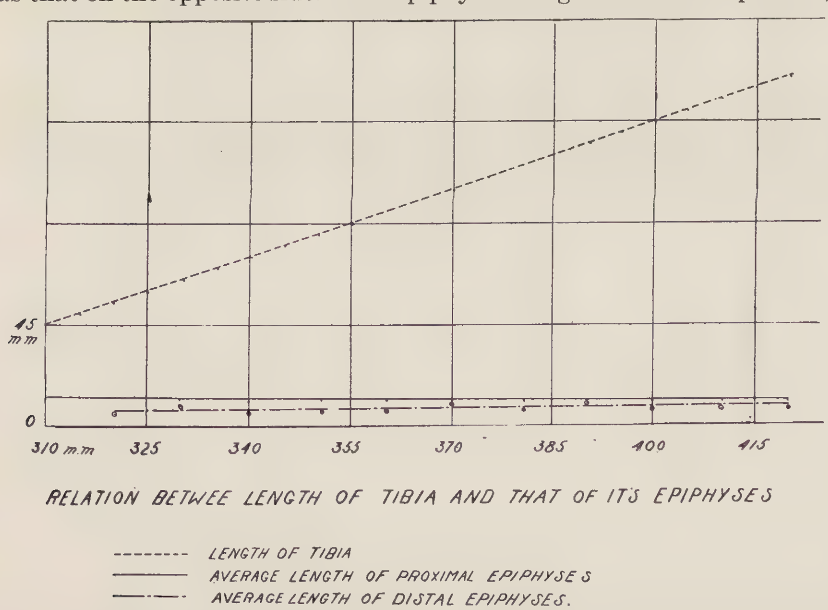

Fig. 2. Similar graphs showing relationship between the length of the tibia and that of its epiphysis.

but the length of tibiae only 24.5 percent. The two were wholly uncorrelated as shown in table 5. This table shows an even greater lack of correlation between tibial length and epiphyseal height than in case of the humerus. Tibiae from 32.0 to 40.0 cm. in length may have distal epiphyses ranging from 7.0 to 10.5 mm. in height. That is, although the bones may vary but 25 percent in length, the epiphyses may vary 50 percent. Moreover, there is no correlation between the length of a tibia and that of either its proximal or distal epiphysis. Fig. 2 plotted in a similar manner to that for the humerus, makes this evident. The graphs of the length of the tibia and those of the lengths of its proximal and distal epiphyses again show the latter as approximately horizontal, instead of the rapidly ascending lines as the graph for bone length in this figure.

The percentage which the epiphyseal height forms of the bone length was also computed for each humerus and tibia. The results are given in Tables 1 and 3. From Table 1 it will be seen that the proximal epiphysis of the humerus forms from 4.15 to 7.06 percent of the bone length, a fluctuation of almost 3 percent of humeral length, for the 84 bones in which it was determined. The average percentage epiphyseal height was 5.58 percent. As shown in table 3, the proximal epiphysis of the tibia forms a smaller and more constant percentage of the length of the bone. The limits are 2.27 and 3.92 percent, with a different of 1.65 percent. The average for 58 bones is 3.12 percent. The distal epiphysis forms a smaller percentage of the length of this bone and varies but 1.12 percent. In the 55 bones measured the average epiphyseal height was 2.29 percent of the tibial length.

Fig. 3 graphically illustrates the results obtained for these bones. The abscissa represents the percentage that the epiphyseal height is of the total bone length and the ordinate the frequency with which the particular epiphyseal length was met. A comparison between the proximal epiphysis of the tibia and that of the humerus is interesting. The average length of the humerus is 32.29 cm., while that of the tibia is 37.52 cm.—the latter being approximately 7.5 percent longer than the former. Nevertheless the average length of the proximal epiphysis of the humerus, the shorter bone, is both relatively and absolutely greater than the corresponding length of the proximal epiphysis of the tibia. Expressed in percentages of bone length the proximal epiphysis of the humerus forms 5.58 percent and that of the tibia but 3.12 percent of the length of the respective bone. It is regrettable that the material available does not permit a similar comparison between the distal epiphyses of these bones.

THE NUTRIENT FORAMEN OF THE TIBIA

In determining the position of the nutrient foramen of the tibia, measurements were made to the point at which the canal entered the compacta completely. The groove so often found more proximal to this point was disregarded.

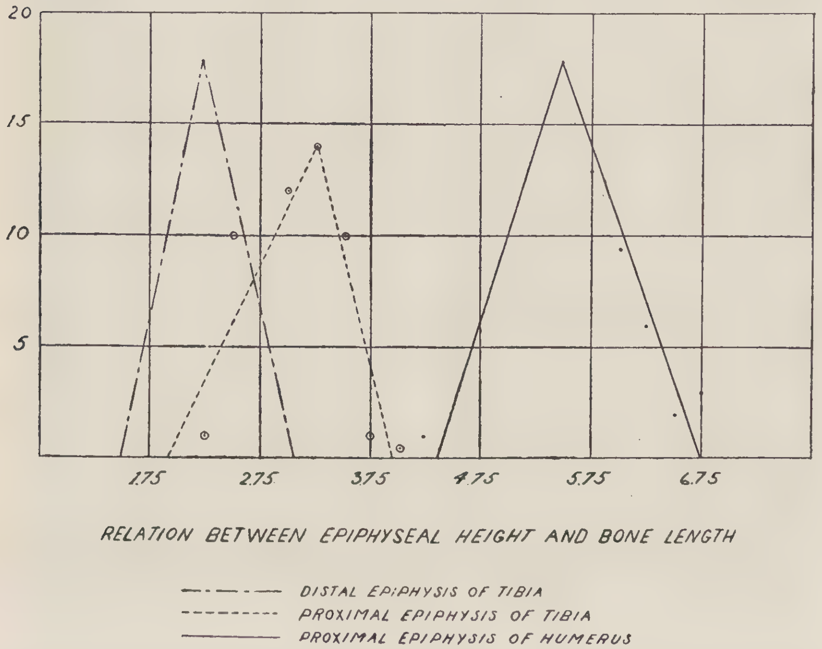

FIG. 3. Graphs showing the frequency of occurrence of different epiphyseal height expressed in per cent of bone length.

Upon examining a number of the tibiae it was evident that the position of the nutrient canal may lie anywhere in the transverse plane between the interosseous crest laterally and the popliteal line medially. It was found possible, however, to group the bones into three classes with respect to the location of the main nutrient canal in a transverse plane.

1. Foramen at or just medial to, the interosseous crest.
2. Foramen lying midway between the interosseous crest and the popliteal line.
3. Foramen near, or at, the popliteal line.

FIG. 4. Three tibiae illustrating the latero-medial and proximodistal location of the nutrient foramen.

The three bones shown in Fig. 4 illustrate these classes. Three of the 108 tibiae examined had two somewhat smaller nutrient foramina in

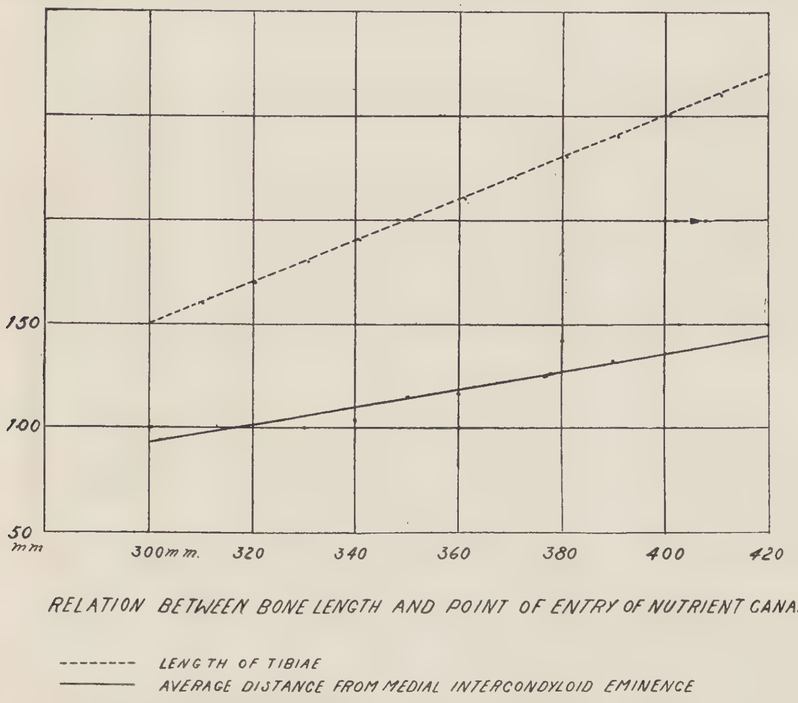

FIG. 5. The relation between bone length to the distance of the point of entry of the nutrient canal from the proximal extremity of the tibia.

place of the usual one and were not classified; the 105 remaining bones gave conditions as follows:

Number of bones	Side	NUTRIENT FORAMEN: Class 1	2	3	Percentage in each class 1	2	3
46	R	30	10	6	*65.2*	*21.7*	*13.0*
59	L	35	12	12	*59.3*	*20.3*	*20.3*
TOTAL 105		65	22	18	*61.9*	*21.0*	*17.1*

In one bone placed in Class 3 the canal lay medial to the popliteal line. Four bones were found with the canal on the popliteal line and 2 with canals on the interosseous crest.

The cranio-caudal position of the canal was determined by measurement from the most prominent point of the intercondyloid eminence. The

results for the 108 bones are given in Table 4. The data set forth in the preceding table show that there is considerable variation in the height at which the canal was found. A comparison between the distance from the proximal extremity of the bone to the site of the foramen and the length of the tibia is made in the correlation table below. Although the correlation between the length of the bone and the point of entry of the canal is far from perfect it nevertheless exists in these bones as may be seen in Fig. 5. The upper broken line represents the increasing lengths of the tibiae and the lower continuous line the increasing distance from the intercondyloid eminence to the nutrient foramen of the bone with a length indicated below. The two graphs are approximately parallel indicating that the longer the tibia the greater the distance from the proximal extremity to the nutrient foramen.

TABLE 6

THE CORRELATION BETWEEN BONE LENGTH AND PLACEMENT OF THE NUTRIENT FORAMEN

	LENGTH IN CENTIMETERS FROM INTERCONDYLOID EMINENCE TO NUTRIENT CANAL							
Length of Tibia cm.	9	10	11	12	13	14	15	16	Total
30		1							1
31				1	1				2
32									0
33	1	4	1						6
34	1	5	2	1					9
35		2	4	7	1				14
36		1	5	7	2				15
37		1	7	4	5				18
38			2	5	8	1	1		17
39		1	1	6	1				9
40	1			2	4				7
41					2	3		1	6
42							1		1
	3	15	22	33	24	5	2	1	105

An examination of Table 6 shows that the nutrient foramen of the tibia often is situated at from a quarter (24.8percent) to almost a half (41.9 percent) of the length of the bone from the proximal extremity and that it is found most frequently at one third of this distance. Rauber, 1868 found the variation in location of the nutrient foramen from the beginning to the end of the middle third of the bone and recognized that it may be displaced medially. He also found the nutrient foramen absent in 3 out of 8 bones, an observation not verified in this series, in none of

which it was absent. Hrdlička, 1898, found that the nutritive foramen lies at a variable distance from the upper articular surface of the tibia in different and on the two sides in the same subjects, and that it is double in one percent of the cases.

	Number of bones	Side	Percentage of distance bet. intercondyloid eminence and nutrient foramen, in bone length
	47	R	*33.0*
	58	L	*33.5*
Total	105		*33.2*

The nutrient foramen of the tibia then is located most frequently slightly medial to the interosseous crest and at the lower margin of the most proximal third of that bone.

The writer gratefully acknowledges the guidance of Professor Meyer who suggested these topics to him and regrets with him that it was not feasible to try to determine the sex of each bone. Nearly all of them were from white males, however.

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Rauber, August, 1868. Ueber die Nerven der Knochen des Vorderarms und Unterschenkels. München. 24 pp., 2 pl.

LITERATURE

VARIATION: SKELETAL

A Study of the Ossification Centers of the Wrist, Knee and Ankle at Birth, with Particular Reference to the Physical Development and Maturity of the New Born. By Adair (Fred L.) and Richard E. Scammon—*Am. J. Obst. & Gyn.*, 1921, II, No. 1, Repr. 28 pp.

The inferior femoral epiphysis judging from all available data, is present in about 1 case in 20 in the eighth fetal month, in 1 case in 3 in the ninth month, in 6 cases in 7 in the tenth month and in about 19 cases in 20 at full birth (full-term infants). If not present at birth, the center appears before the close of the first postnatal month. In the series under discussion the center was present in 98 per cent of all newborn children.

The superior tibial epiphysis, judging from all available material, is almost never present before the ninth fetal month. It is found in 1 case in 17 in the ninth month, about 2 cases in 5 in the tenth month and in about seven-eighths of all full-term newborn children. It was present in 81 per cent of the cases in the series under discussion.

The cuboid, according to all available data, first appears at about the beginning of the ninth fetal month. It is present, on the average, in about 1 case in 25 in the ninth month, in about 1 case in 4 in the tenth month, and in about 3 cases in 5 in full-term newborn children. In the series under discussion the center was present in a much smaller per cent of all cases than is reported by other investigators (38 per cent).

Two carpal ossification centers, those of the os capitatum (os magnum) and of the os hamatum (unciform), may be present in the newborn. In the series under discussion the os capitatum was present in 15 per cent and the os hamatum in 9 per cent of all cases.

There is a close relation between total body-length and frequency of ossification in the several centers discussed in this paper. A similar, but less close, correlation exists between frequency of ossification and the body-weight.

In the material under discussion the correlation of body-weight, total body-length and frequency of ossification with menstrual age was quite close for the middle members of the series ranging in menstrual age from 270 to 300 days. But the outlying cases (having a menstrual age of less than 270 or more than 300 days) show little relation between these measures of bodily development and age as determined from the menstrual history.

The evidence points to the conclusion that ossification proceeds slightly more rapidly in females than in males during intrauterine life

even though the weight and dimensions of the females are less than those of the males.

The observations show no direct evidence of any relation between parity and the rate of ossification in intrauterine life.

Variations in the *number* of ossification centers present for individuals bones were limited to the os capitatum and os cuboideum. The latter is formed from an extremely variable number of centers. When anomalies in the number of centers are present they are often asymmetrical.

Variations in the order of appearance of centers were decidely unusual in the material under discussion, being confined to premature ossification of the os cuboideum (2 cases) and of the premature ossification os capitatum (2 cases).

The usual order of appearance of the centers under consideration is as follows: (a) Inferior femoral epiphysis; (b) Superior tibial epiphysis; (c) Cuboid; (d) Os capitatum; (e) Os hamatum.

THE OSSIFICATION CENTERS OF THE FETAL PELVIS. By Adair (Fred L.)—*Am. J. Obst. & Dis. Wom. & Child.*, 1918, LXXVIII, No. 2. Repr. 25 pp.

The first ossification center of the pelvis to appear is in the ilium about the 60th to the 65th day of fetal life in embryos with a C. R. length of from 30 mm. to 35 mm. There are no separate secondary centers.

The median center of the first sacral vertebra is the next to appear about the 74th to 76th day in embryos having a C. R. length of 51 to 52 mm.

The lateral sacral centers first appear when two or three median centers are present, in embryos 80 to 82 days old having a C. R. length of 65 mm.

The ischial center appears about the 94th to 98th day in embryos whose C. R. measurement is from 88 mm. to 100 mm.

The oubic center is present on the 119th day in an embryo with a C. R. length of 133 mm. At this time all other centers which appear until just prior or subsequent to birth are usually apparent.

Practically all antenatal pelvic ossification centers are evident by the end of the 19th week of fetal life.

SUR UN CAS D'OSSIFICATION DE LA CHAINE HYOÏDIENNE. By Dubreuil-Chambardel (Louis)—*Bull. & Mém. Soc. d'Anthropologie* Paris, 1920, I, Sér. 7, Nos. 1-3, 79-82.

Author reports a new case of a complete ossification of the hyoid complex, in a Frenchman 55 years of age.

In giving the literature of these cases he does not include the valuable study on the ossification of the hyoid in the Indians by Dr. J. L. Wortman, assisted by Dr. H. ten Kate (*Am. Anthrop.*, 1889, II, 81; *C. R.* VII, *Cong. Intern. Amer.*, Berlin, 1888; *Mem. Nat. Ac. Sc.*, 1893, VI, 203-211).

SUR QUELQUES DIFFÉRENCES SEXUELLES DANS LE SEQUELETTE DES MEMBRES SUPÉRIEURS. By Mendes-Corrêa (A. A.)—*C. R. Ac. Sc.* Paris, 1921, T. 172, 817-19.

Author calls attention to the value, in sex diagnosis, of a number of indices obtained on the bones, such as the index of robustness of the clavicle, humerus, radius and ulna, and the scapular indices, including that of the glenoid cavity (relatively broader and lower in the male than in the female).

Bifurcate Clavicle. By Rutherfurd (Henry)—*J. Anat.*, 1921, LV, Part 4, 286-287.

The subject of the abnormality was a Scotch youth of 16. A skiagraph of the left shoulder showed "that there were two clavicles or rather that the clavicle was bifurcate in its outer half, the upper branch running upwards and backwards from the middle of the normal one, which passed outwards to the acromion. That there is such a gap in the skiagraph between clavicle and acromion is to be accounted for by the cartilaginous condition of that process; ossification only beginning in the epiphysis there at 15 to 16 years."

An operation showed the duplicating parts to have all the characteristics of that portion of clavicle. The other shoulder showed nothing abnormal. Author can only explain the case by assuming a duplication of the outer center of the bone. No previous record of such an anomaly has been discovered.

On Sesamoid and Supernumerary Bones of the Limbs. By Bizarro (A. H.)—*J. Anat.*, 1921, LV, Part 4, 256-268.

After describing the various sesamoids of the upper and lower extremity with their variations and frequency of occurrence, the author, in considering their cause reaches the conclusion that "Phylogeny and function combined appear to be the two causes of sesamoid formation and development. The former originates and plants, as it were, the seeds for their formation, and the latter, acting daily and with every movement, promotes the increase in size of these structures. It is hardly possible to accept either of these theories separately, and the only obscurity remaining lies within the elastic boundaries indicated by the term phylogeny."

Bilaterale Asymmetrien im Bau des menschlichen Rumpfskelettes. By Stieve (H.)—*Zeitschr. f. Anat. u. Entwicklungsgesch.*, 1921, LX, 307–410.

A series of cases of more or less marked asymmetries in individual vertebrae and ribs and in the entire thorax, with special consideration of the sternum, is described in great detail. The asymmetries of the vertebrae, as observed by the author, are of a descriptive more than of a metric nature and do not include the bodies of the vertebrae. The second half of the paper is devoted to a discussion of the findings. Here Rosenberg's theory of transformation processes in the spine is attacked chiefly on the ground that both atavistic and progressive conditions may occur in individual spines. Such a coincidence, however, is by no means unusual, and it is difficult to see why it should be regarded as

a contradiction. Finally the asymmetries are explained, or rather defined, as partially independent variations in the two halves of the body.

A. H. Schultz.

Zur Anthropologie des Brustbeines. By Gersch, (W.)—*Anatom. Anz.*, 1921, LIV, 347–351.

A short description of the sterna of two adult negroes of unknown locality, of two adult and one infantile Herero, and of one newborn Hottentot.

Die verschiedenen Formen des Condylus tertius und ihre Entstehungsursache. By Bolk, (L.)—*Anatom. Anz.*, 1921, LIV, 335–347.

There are two types of tertiary condyles, one in which an articular surface is formed with the dens epistrophei and a rare type in which there exists an articular surface between the atlas and the skull. According to the author, in early development the occipital condyles lie more forward on the foramen magnum than in adults and reach almost to the midsagittal plane. During later development the condyles migrate laterally; their anterior portion normally disappears and their posterior ends grow in a compensatory way. In skulls of children this migration is sometimes found to be incomplete, especially as regards the anterior reduction, causing very long condyles which approach each other closely in the middle. The tubercula basilaria, a not uncommon occurrence, are remnants of the medial ends of the embryonic or primary condyles. These medial ends, according to Bolk, possess at times a tendency to active growth. All stages of more or less complete fusion of these tubercles have been observed. In the most extreme cases one median process is formed with an articular surface for the epistropheus—a true condylus tertius. Such cases were never found in infantile skulls. A different kind of condylus tertius is the narrow and slender process which originates from the ossification of the ligamentum apicis.

A. H. Schultz.

Defects of the Patellar Border. By Todd (T. Wingate) and W. C. McCally—*Ann. of Surgery*, Phila., December, 1921, 775–782.

The authors describe a series of human patellae with defects in the upper part of its outer border, and thus summarize their observations:

"There is a condition of the patella occurring in about three per cent of human beings characterized by more or less marked defect of the upper and outer part of the bone. Certain minor defects which are ill marked and show up best when lipping of the patella becomes a prominent feature are not included in the estimate of three per cent. These occur much more frequently.

"The area in which patellar defect occurs presents certain differences from the remainder of the bone even in the cartilaginous condition. In the adult lipping is exceedingly slow to make its appearance in this area.

Pathological conditions of the articular surface are prone to present themselves in this area.

"The area to which reference has just been made is known as the area of emargination. It is associated with the attachment of the vastus lateralis tendon. Patellar emargination may occur as a very slight defect. There may be a much larger defect in the bone which may or may not be occupied by a separate ossification. Again, there may be incomplete separation of the patellar portions. Associating with or occurring in place of patellar defect there may be a condition of deep pitting of the articular surface.

"No indication of recent or old callus formation is present on any of our specimens, whether of complete or incomplete separation of the patellar portions. No indications of inflammatory processes occur in relation to either patellar defect or excavation. Lipping of the margins of the emarginate area occurs with age; this must not be mistaken for callus formation. A history of trauma is not given by the cases in which patellar defect is found.

"The condition occurs on both sides twice as frequently as upon one side. There is no convincing evidence that the condition occurs more frequently with increasing age. We have been able to present all phases of the development of the condition, although the results of our investigations upon children are unsatisfactory.

There is no doubt that the patella sometimes ossifies from separate centers in the vertical axis. We have presented specimens showing the probability of other centers of ossification in individual instances.

As the result of the findings just summarized we believe that the condition is an anomaly and not a fracture."

In 1916, Hrdlička (Bull. 62, Bur. Am. Ethn., 89, pl. 28) reported and pictured the anomaly, calling it the "vastus notch." It is frequent in Indians, and occurs in other races. It is a morphological peculiarity.

Das Sprungbein des Australiers verglichen mit dem des Europäers. By Kaschel (Ernst)—*Zeitschr. f. Anat. u. Entwicklungsgesch.*, 1921, LXI, H. ¾, 191–230.

A study of 34 adult Australian tali and of a comparative series of 40 tali of whites. In Australians the talus is smaller, absolutely as well as in relation to the tibia, than it is in Europeans; it is also relatively broader and lower. The trochlea, in proportion to the entire bone, is smaller and more curved in Australians. The collum is shorter and deviates more from the sagittal plane than in whites, and the caput is smaller with less torsion. There are many signs which speak for a marked mobility in the Australian foot.

A. H. Schultz.

VARIATION: TEETH

L'Age dentaire comme signe du dévelopment total. By Matiegka (J.)—*Rev. Anthrop.*, 1921, XXXI, 258-260.

Author regards the "dental age," or indications of dentition as to stages of development of an individual, especially when considered

with other outgoing characteristics of importance, as a valuable index of general systemic advance or retardation, and recommends its use in medical work with school children. Gives standard normal (average) data on children of Czechoslovakia.

A Toothless Type of Man. By Thadani (K. I.)—*J. Hered.*, 1921, XII, No. 2, 87-88.

In a preliminary report the author gives the following data of interest on these peculiar occurrences:

"There occurs in the Hindu Amil community of Hyderabad Sind, a town in India a type of man who have no teeth. These men are further characterized by a bald head and an extreme sensitiveness to heat. They are known as "Bhudas," which literally means "toothless." The following facts are known about them:

(1) When such a man (a Bhuda) marries a normal girl having both parents free from these defects, all the children both males and females, are apparently normal—that is to say apparently free from the defect.

(2) When the F_1 males marry normal females, having both parents normal, their children, both males and females, are apparently normal.

(3) When the F_1 females marry normal males, their female children are apparently normal, while the male children are "Bhudas."

(4) No case is known in which a toothless man has married the daughter of a "Bhuda."

(5) No females have been found showing the anodont condition."

The author's conclusions are:

The toothless man seems to be an example of regressive mutation.

The phenomenon of heredity in the toothless man is strictly a case of sex-linked inheritance, as all the existing facts are in conformity with our theoretical expectations based on Mendelian laws of Segregation and Dominance."

Dental Doubles and Dental Fusions. (In Czech). By Pachner (A.)—*Zubní Lékařství*, Prague, 1921, XXI, 97-102.

In reporting these new and interesting cases of fusion of teeth, (through 2-3 u. m., 2-1 pm.) with impacted teeth the existence of which was not known of up to the time of extraction, and on the basis of study of other cases, the author comes to the conclusion that no fundamental or etiological difference exists between the so-called (Nessl) double or synostosed teeth, supposed to have grown together after development as a result of some pathological condition, and fused teeth of purely developmental origin. He regards all these conditions as merely grades or varieties of a developmental anomaly.

Über Zahnanomalien bei congenitaler Lues. By Kranz (—)—8°; (Meusser), 1920.

Author shows that the so-called Hutchinson's teeth may be produced by mechanical condition in rachitics and others, in whom syphilis may safely be excluded; also as hypoplastic effects in endocrine disturbances.

I MOLARI UMANI ESACUSPIDI E L'INDICE DI MOLARIZZAZIONE.—By Giuffrida-Ruggeri (V.). *Rendc. Acad. Sc. Fis. e Med.*, Napoli, 1921, XXVII, ser. 3ª.

The paper deals with some investigations in the morphology of dental crowns in man and the greater anthropoids. Author distinguishes two types of hexacuspid crowns in the inferior molars of man; an oblong type in which the six cuspids are in pairs in two parallel lines, and an almost circular type in which the six cuspids are arranged in a rosette. The oblong type is found in M^2 and in Mi^3 the rosette type is found only in M^1 (Mi^3). He found a second hexacuspid milk molar in same jaw in which the first permanent molar presented an initial hexacuspidism. This induced him to make a comparison between the size of the second milk molar and the first permanent molar, making the length of the latter equal 100 and the same for the width. One has thus an *index of molarisation* which for the second milk molar of the lower dental arch averages 87.3, whilst in the chimpanzee it is 81.6, in the orangs 81.3 and in the gorilla 78.9—always examining infantile jaws which have the 2nd milk molar together with the first permanent molar; so that in this index we have a new distinguishing characteristic between the greater anthropoids and man.

G. R.

THE ANATOMY AND PHYSICS OF THE TEMPOROMANDIBULAR JOINT. By Wilson (George H.)—*J. Nat. Dent. Ass.*, 1921, VIII, 236–241.

"The science of dental prosthetics as taught by Bonwill comprises the statements that: (1) The mandible is a lever of the third class; (2) The mandible is an equilateral triangle; and the mandibular movements are from fixed rotation centres. An investigation of these hypotheses on a large number of lower jaws and skulls has convinced the author that they all are more or less erroneous."

Much the same subject is discussed in another of Dr. Wilson's articles, "THE FUNDAMENTAL PRINCIPLES OF ARTIFICIAL DENTURE CONSTRUCTION," but he adds a series of observations on the "curve of Spee" showing its variation.

In conclusion and as a practical application of the results of his studies he "wishes to state emphatically that he does not believe in standardization in denture construction *for thereby individuality and esthetics are destroyed.* We are more than artisans." He "believes sincerely in the fundamental principles of anatomy, physics and esthetics and how to apply them, but not in a rule of thumb."

THE DIAGNOSIS OF MALOCCLUSION WITH REFERENCE TO EARLY TREATMENT. By Le Roy Johnson (A.)—*J. Dent. Research*, Boston, March 1921, III, No. 1, v–xx.

"Slight irregularities of the deciduous teeth and of the permanent teeth during the transition period, should be interpreted in terms of growth and development, also in recognition of the law of normal variability and of the limits imposed by hereditary, environmental and

constitutional factors; and such irregularities should be considered abnormal only when they interfere with normal growth processes. When doubt exists, the nature of the problem bids us make careful records and observe. It is not reasonable to place a pattern of perfection upon the dental arch of a child as a measure of its normality. Because a tooth can be moved is not sufficient reason for moving it."

VARIATION IN OCCLUSION. By Hellman (Milo)—*Dent. Cosmos*, June, 1921, repr. 12 pp.

The author endeavors to show that "occlusion of the teeth is a biologic phenomenon, and like all other manifestations of life it is subject to the same general laws." A study of crania and biometric considerations lead him to the following conclusions:

"The concept of the so-called "Normal" in occlusion must assume a more concrete form to enable us to treat the problem entailed in a scientific manner. The "Normal Occlusion" of the teeth conceived by the orthodontist to present 100 per cent perfection is a myth. It has no biologic justification and no scientific foundation. . . . The evidence obtained points to the fact that although the *imaginary ideal* of the orthodontist cannot be found, *Nature's ideal* as expressed in the form of *type*—represented by the *average and its standard deviation*—has been demonstrated.

The *type of occlusion* in man is shown to be represented by a masticatory apparatus with an average of approximately 90 per cent perfect and a standard deviation of approximately 6 per cent. . . . The *average*, it may be said, represents the *"normal"* and the *range of variability*, the *type*. These values are based entirely upon the physical characters of the occlusal factors of the teeth. . . .

"In view of these facts we must use Johnson's newly proposed term "Individual Normal" reservedly." From the viewpoint advanced author would prefer to substitute the phrase "individual variation."

VARIATION—SOFT PARTS

WHAT IS THERE IN PHYSIOGNOMY? 1. THE SIZE OF THE NOSE.—Woods, (Frederick Adams). *J.Hered.* XII, Aug.-Sept. 1921, 301–318.

As a result of his investigations on portraits of great men and on some living Americans, it appears probable to the author that if "each grade of mental superiority is associated with a little larger facial trait, such as the nose, it is at least difficult to see how favorable home environment, good education or a good run of luck, could make a man's nose larger." Too little attention has been given to the important age factor; and there are other conditions that must be considered.

FISTULA AURIS CONGENITA. By de Oliveira (J.M.)—*Trab. Soc. Portug. de Antrop. e Etn.*, 1921, I, No. 3, 85–122.

Describes a series of cases of a hereditary anomaly of the external ear, which manifests itself in the form of a blind canal (improperly

termed "fistula"), 5–20 mm. long and 1–2 mm. in diameter, located in or just above the notch between tragus and helix, in or just anterior to the lowest portion of the ascending part of the helix.

Die Gesichtsmuskulatur von 14 Papua und Melanesiern. By Harslem-Riemschneider (L.)—*Zeitschr. Morph. u. Anthrop.*, 1921, XXII, 1–44.

A well-illustrated report on dissections of the facial musculature of 14 Papuans and Melanesians. The most striking general result is the great frequency of a continuous connection between facial muscles which in the white are usually separate. This is considered a lesser degree of differentiation and a primitive condition. Traces of a musculus transversus nuchae, as found in negroes, were entirely absent in this material. The musculi risorius, zygomaticus, and auricularis anterior were found to be missing in a surprisingly high percentage of cases.

A. H. Schultz.

Zur Anthropologie der Kopfweichteile. By v. Eggeling (H.)—*Anatom. Anz.*, 1921, LIV, 54–60.

Description of the muscles of the head in a 25 year old negro from Guadeloupe. This is intended chiefly as a new record for comparison. The author concludes that his observations confirm previous findings on the head musculature of races other than white, especially the general thickness of the muscles and their slight differentiation in the region between the eyes and the mouth.

A. H. Schultz.

Über die morphologische Bedeutung der blauen Geburtsflecke (Mongolenflecke). By Zarfl (Max)—*Z.f. Kinderheilk.*, Berlin, 1921, XXXI, H. 1/2, 80–97.

In the course of nine years the author observed 19 infants with congenital patches of pigmentation. One of these cases was especially remarkable as the pigmented parts, in a large measure symmetric and of regular outlines, occurred on the scalp. Twelve of the remaining children had but one patch, three had two, two showed three, and in one case there were four patches. Of the 27 patches on the back of the body, 16 were located in the gluteal region, 9 in the lumbar and 2 in the lower dorsal region. In 11 instances the patch was round; in 11 ovoid. The boundaries of the spot were in all of these cases well defined and in size none of them exceeded that of a small coin or an almond. In 6 cases the patches were irregular and much more extensive. All the nineteen children were white children from Austria, Hungary, Moravia and Galicia.

The frequency of occurrence of these patches, which are probably of reminiscent (atavistic) origin, shows a considerable racial variation. They are rare in whites. In his cases the author is inclined to suspect an old-time admixture of a yellow-brown element (Huns or Magyars).

Über die flächenhafte verbreitung der Pigmente in der Haut bei Menschen und Affen.—Toldt (v.K.) jun., *Mitt. Anthrop. Ges. Wien*, LI, 1921, 161–183.

The author discusses and gives interesting new observations on the subject of regional differences in the pigmentation of the skin in man, the apes and various other mammals.

Ueber geschlechtsgebundene Erbanlagen für Augenfarbe. By Lenz (F.)—*Arch. f. Rass. & Gesellsch.-Biol.*, 1920, H. 5–6, 298–300.

Author advances the opinion that the generally somewhat darker pigmentation of hair and eyes in women may to a large extent be a sex-inherited peculiarity ("geschlechtsgebunden erblich"); though there may also be other factors concerned, such as mixture.

Morphologie und Morphogenese des Haarstrichs. By Ludwig (Eugen)—*Z. f. Anat. u. Entwicklungsgesch.*, 1921, LXII, H. 1/2, 59–152.

On 50 white fetuses the arrangement of the lanugo is described in detail, especially the direction of the hair streams and their centers. The following hair centers and crosses are found constantly in man: (1) centers of divergence: 1 vertex center, 2 eye centers, 4 ear centers, and 2 trunk centers; (2) centers of convergence: 2 on ears, 1 on umbilicus, 1 on penis, 1 on scrotum, 1 over coccyx, 2 on elbows, and 2 on hands and on feet; (3) crosses: 1 on forehead, 1 on nose, 4 on ears, 2 in front of ears, 1 each on neck, chest, abdomen, penis, and over coccyx, 2 on shoulders, 2 over ulnae, and 2 on knees. In addition, a great number of accessory centers of both divergence and convergence and of accessory crosses have been noted in the lanugo of this material. No sexual differences exist in the arrangement of hair. These conditions are illustrated by 121 clear and excellent drawings. In conclusion the author discusses his hypothesis that the direction of hair is conditioned by and coincides with the direction of the greatest rate of growth of the epidermis.

A. H. Schultz.

A Contribution to the Topographic Anatomy of the Thymus Gland, with Particular Reference to its Changes at Birth and in the Period of the New-Born. By Noback (G.J.)—*Am. J. Dis. Child.*, 1921, XXII, 120–144.

The location of the thymus is determined early in fetal life and the establishment of respiration obviously has no effect on it.

The thymus in the late fetus and in the new-born is predominantly of the cervicothoracic type, i.e., its position is intermediate between the cervical location in the embryo and the thoracic location of the older infant, child and adolescent.

The thymus in the late fetus and stillborn child has a typical form and quite constant relations. Its lateral surfaces are convex and bulge against the medial surfaces of the lungs. The lungs very rarely extend

at all on its anterior surface, and the thymus very rarely extends at all on the anterior surface of the right ventricle of the heart.

The thymus in liveborn infants has typical form and relations which are similar to those found in young children. It is elongated and molded so that its anterior, lateral and posterior surfaces bear the impress of all the organs with which it is in contact. Its lateral surfaces usually show marked convexities which are occupied by the lungs which pass over the anterior surface of this organ. Unlike the fetal thymus, it usually extends more inferiorly passing over the right ventricle.

The change from the broad or fetal type of thymus to the elongated and molded type found in the liveborn and in the young infant bears a direct relation to the establishment of respiration, and is dependent on the expansion of the lungs. The organ is compressed from side to side by the medial surfaces of the expanding lungs. It is compressed antero-posteriorly by the anterior borders of the lungs which become much thickened early in the establishment of respiration as they gradually overlap the thymus.

In some cases the thymic substance may extend posteriorly at birth to such an extent that the structures situated there are compressed by it. This may be due either to an unusually large thymus or to a very narrow superior thoracic aperture which will not allow the thymus to protrude into the cervical region as it is compressed by the expanding lungs.

The descriptions and illustrations in the literature of the thymus in the new-born child show great confusion. They include both the fetal (broad) and infantile (narrow or elongate) types and the distinction between the two has evidently passed unrecognized. The type of thymus which is the more frequently described as characteristic of the new-born and the infant is the one which the preceding data indicate is usual for the fetus and stillborn as contrasted with the living infant.

Observations on the Capacity of the Stomach in the First Ten Days of Postnatal Life. By Scammon (Richard E.) & Lawrence O. Doyle—*Am. J. Dis. Child.*, 1920, XX, 516–538.

The average physiologic capacity of the stomach in the first day after birth is about 7 gm. This practically doubles in the second day, quadruples on the third and increases almost sevenfold on the fourth. After the fourth day the increase is much slower and the average capacity on the tenth day is 81 gm. or over eleven times that of the first day.

The relative physiologic capacity increases in much the same way as the absolute physiologic capacity. It is equal to 0.21 per cent of the birth weight of the body on the first day, to 1.38 per cent on the fourth day, and 2.43 per cent on the tenth day. The relative maximum capacity is equal to 0.27 per cent of the initial body weight on the first day, to 1.96 per cent on the fourth day and to 3.17 per cent on the tenth day.

The anatomic capacity of the stomach at birth averages 33 c.c. This is increased about one-third in the first three or four days and is a little

more than doubled in the second week. There is no indication of two definite stages in the development of anatomic capacity in the neonatal period corresponding to the two phases of physiologic capacity. Anatomic capacity and physiologic capacity approximate one another about the fourth day. Thereafter physiologic capacity runs parallel to the anatomic capacity but is slightly greater. This agrees with previous findings regarding this relation throughout the greater part of the suckling period.

LENGTH AND POSITION OF THE VERMIFORM APPENDIX IN FILIPINOS. By Garcia, (A.) and Solloza, (J.)—*Phil. J. Sci.*, 1921, XVIII, 707–717.

On 340 Filipinos ranging from birth to 80 years and including both sexes it was found that the appendix has most frequently a retrocaecal position and that it lies higher in children than in adults. The length of the appendix is exceptionally variable; it is relatively greater in younger than in older individuals and greater in males than in females.

A. H. SCHULTZ.

POSITION AND SIZE OF THE KIDNEYS AMONG FILIPINOS. By Nañagas, (J. C.)—*Phil. J. Sci.*, 1921, XVIII, 695–703.

Observations and measurements made on 24 male and 24 female Filipinos led to some interesting results: The kidneys in general are at higher levels in the male than in the female. In males the upper pole of the kidney lies most frequently on a level with the lower half of the twelfth dorsal vertebra. In both sexes the right kidney is farther from the midsagittal plane than is the left one. In general the left kidney is larger than the right and is larger in females than in males.

A. H. SCHULTZ.

THE NORMAL SPLEEN. By Nishikawa (Y.) and S. Kawagita—*Tokyo Igakukai Zasshi* (*Proc. Tok. Soc.*), 1919, XXXIII, 1–41 (In Japanese; abstract in German).

The study is based on 522 normal spleens selected from 3,300 autopsies; the dimensions of the organ were found to be as follows:

	Male				Female			
Age	No. of Cases	Mass in cm.	Weight in grams	Ratio of spleen to body weight	No. of Cases	Mass in cm.	Weight in grams	Ratio of spleen to body weight
1 yr.	28	6.8x3.5x1.5	21	1–242	22	6.1x3.3x1.5	17	1–287
2–6	20	7.6x4.5x2.0	30	1–264	10	8.1x4.1x1.6	30	1–316
7–15	18	9.1x5.0x2.2	54	1–385	6	8.8x5.0x1.8	57	1–424
16–24	27	10.7x6.3x2.4	89	1–435	32	10.4x6.4x2.6	98	1–349
25–40	58	10.5x6.8x2.7	100	1–397	61	10.7x6.3x2.6	97	1–402
41–60	89	10.4x6.3x2.4	86	1–507	41	9.6x5.6x2.4	76	1–413
60+	50	8.5x5.3x1.9	65	1–514	59	8.5x5.0x2.2	56	1–605

SEVERANCE REVIEWS.

(Compare in this connection Bean and Baker, Racial Characteristics of Spleen Weight, AM. J. PHYS. ANTHROP., 1919, II, No. 1.)

On the Patency of the Foramen Ovale in Filipino Newborn Children. By Nañagas (Juan C.)—*Anat. Rec.*, 1921, XXI, No. 4, 339-352, 3 fig.

Filipino foetuses in general are smaller and lighter than European or American foetuses.

The general average weights of foetal hearts in our series was about the same as those reported by other observers. Cardiac weights increased proportionately with body weight, this increase was, however, smaller than given in Scammon's table 33.

Cardiac dimensions showed a definite and proportionate increase with the increase in cardiac weights; this increase, however, was less marked in hearts heavier than 20 grams, probably because of greater thickening of cardiac walls.

The thickness of the two ventricular walls in our cases was about the same as reported by other workers, but in our series the left ventricle was uniformly the thicker.

The thickness of both ventricles definitely and proportionately increased with the cardiac weights.

The right atrioventricular orifice showed the largest circumference; the aortic the smallest. The left atrioventricular, the aortic and the pulmonary openings steadily increased in size with the weights of the hearts, but the right atrioventricular orifice remained almost stationary in hearts heavier than 20 grams.

Filipino foetuses and foetal hearts of this series were probably normal in development.

The foramen ovale was present in three different shapes: circular, oval and triangular; the first of which was the smallest and most frequently encountered and the last type the largest and least common.

The circular and oval types of foramen ovale were larger in males than in females, while in the triangular form the conditions were reversed. The circular type was more commonly encountered in females, while the other two types were more frequent in males.

In location the foramen ovale was most commonly found in the middle section of the posterior two-thirds of the interatrial septum.

Our percentage of patency of the foramen ovale was greater than reported by Addison. More cases of patency were met in females.

The area of the opening of patency was largest in males. It varied from 1 to 27 sq. mm., the majority of cases were 2 to 5 sq. mm.

In position the opening was more commonly found above the middle horizontal plane of the foramen ovale.

No definite relation could be observed between the sizes of the hearts and of the foramen ovale, nor between the size of the foramen ovale and the aperture of patency.

The author feels "that we are not in possession of sufficient data to offer conclusions explanatory of the high frequency of occurrence of patent foramen ovale in Filipinos;" he believes however "that this fact should be taken into account when considering the various and different etiological factors of our excessive infant mortality."

Die Gesichtmuskulatur von 14 Papua und Melanesiern. By Harslem-Riemschneider (Lina)—*Z. f. Morph. & Anthrop.*, 1921 XXII, H. 1, 43 pp.

After pointing out what has been done in these respects on other races, the author gives the results of detailed examination of the musculature of 14 adult Papuans and Melanesians (13m. 1f.). While nothing radically different from the European was found, there were a number of interesting differences, the principal of which was a lesser differentiation in individual muscles. For details relating to the individual muscles reference must be made to the original. The most remarkable of these is the almost complete absence (in 24 facial sides) of the Auricularis anterior.

Musculus Sternalis in Filipinos. By Yap (Sabas E.)—*Anat. Rec.*, 1921, XXI, No. 4, 353-371, 2 pl. 10 fig.

The author gives interesting statistics on the frequency of occurrence of this muscle in different peoples, including some Filipinos, and discusses the significance of the muscle.

VARIATION—BRAIN; NERVOUS SYSTEM

Anatomie des menschlichen Gehirns und Rückenmarks auf myelogenetischer Grundlage. By Flechsig (P.)—Pt. I, 4°, Leipzig, 1920, 60 pp. 25 pl.

The work embodies the first results of highly original and important researches on internal functional organization of the brain, its subdivision into special sensory or association fields, and time as well as histological differences in the development of these fields. A pioneer work which opens a great new field in brain study of much anthropological promise.

Ueber die Variationen der Hirnfurchen des Schimpansen. By Fischer (E.)—*Verh. anatom. Ges., Ergzh. Anatom. Anz.*, 1921, LIV, 48–54.

A study of the fissures in 26 well preserved brains of chimpanzee from the interior of Cameroon. The most interesting result is the conclusion that the brain of the chimpanzee is fully as variable as that of the white man. As in the human brain, the Sylvian fissure in chimpanzee is longer on the left side than on the right; only four brains showed a reverse relation.

A. H. Schultz.

Studi sul midollo spinale dello cimpanzé. By Sergi (S.)—*Riv. di Antrop.*, 1920–'21, XXIV, 89 pp., 10 charts.

Compared with that of man, the spinal cord of the chimpanzee shows the following peculiarities:

There is in the chimpanzee a relatively smaller development of the grey as well as white substance of the dorsal columns, but a relatively

larger development of the antero-lateral columns; but these differences are less accentuated in the cervical than in other regions of the cord.

The relative volume of the whole cord is larger in the chimpanzee than in man in the cervical portion (relatively larger upper limbs in the ape) and in the sacral region (larger visceral parts) but smaller in the thoracic and lumbar region (relatively smaller volume of viscera controlled by these parts and of the lower limbs). In the chimpanzee the thoracic part of the spinal cord is also relatively longer than in man.

VARIATION: MENTAL, PHYSIOLOGICAL

THE MORPHOLOGIC ASPECT OF INTELLIGENCE. By Sante Naccarati. *Columb. Univ. Contrib's to Philo. & Psychol.*, 1921, XXVII, No. 2, 8°, N. Y., 44 pp.

Basing himself upon the examination of a series of students, the author reaches the following main conclusions:

"Intelligence cannot be correlated with a simple physical trait such as height, weight, cephalic index, etc. A basis for correlation must be found in a compound physical trait which is made up of several anthropometric traits.

"By morphologic type is meant the physical constitution of the individual when the development of the extremities and that of the trunk are reciprocally considered and compared. 'The Morphologic index' of an individual is given by the ratio value of the extremities (length of one upper and one lower limb) to the volume of the trunk. The morphologic type is the outcome of hereditary and accidental factors.

"Owing to racial tendency toward brachiskely and dolichoskely, one should avoid putting in the same group, when taking the morphologic index, individuals of different races (namely the white, the yellow and the negroid).

"My experimental study has shown that a positive correlation exists between intelligence and the ratio of height to weight. The average coefficient of correlation found in the group of 221 students was equal to +.228 with a P.E. equal to .044. No correlation was found in any one of the groups examined between height and intelligence. Similarly no correlation was found to exist between lung capacity and intelligence in 136 of the students making the group of 221, whose lung capacity had been measured. Weight gave a negative correlation."

THE ENERGY REQUIREMENTS OF GIRLS FROM 12 TO 17 YEARS OF AGE. By Benedict (Francis G.) and Mary F. Hendry. *Bost. Med. & Surg. J.*, 1921, Vol. CLXXXIV, 217–22; 259–62; 282–6; 297–306; 329–334; repr. 90 pp.

A careful study of several groups of girls in Boston, the results of which were as follows:

The average, minimum, resting pulse rate per minute of girls from 12 to 17 years of age, just before rising in the morning was found to be 81 at 12 years, 77 at 13 years, 77 at 14 years, 83 at 15 years, 71 at 16 years and 74 at 17 years.

The insensible perspiration for these girls per kilogram of body weight per hour was as follows: 0.72 gram at 13 years, 0.71 gram at 14 years and 0.77 gram at 15 years.

The respiratory quotients of groups of 12 girls each, about 7 to 8 hours after a light meal, were 0.81, 0.81, 0.78 and 0.79.

The caloric requirement of young girls during 10 hours of "bed rest" was on the average 55.0 calories per individual per hour.

The average 24-hour basal heat production of groups of girls from 12 to 17 years of age was 1250 calories per individual, irrespective of age.

The heat production per kilogram of body weight per 24 hours decreases regularly with increasing age from 29.9 calories at 12 years, 2 months, to 21.7 calories at 17 years. The curve indicating the general metabolic trend is throughout its entire length materially below the few scattered observations of earlier writers.

The heat production per square meter of body surface per 24 hours likewise decreases, but not so regularly, with increasing age, ranging from 928 calories at 14 years to 745 calories at 16 years.

The metabolism of groups of young girls can be predicted from the general curve indicating the heat production per kilogram of body weight referred to age to within an average error of ± 3.1 per cent. The prediction for the heat production per unit of body weight is somewhat better than that per unit of surface area.

The curves representing the heat production per kilogram of body weight referred to weight and per square meter of body surface referred to weight for these groups of girls from 12 to 17 years of age blend with remarkable uniformity with similar curves based upon the measurement of a large number of normal girls from birth to 12 years of age.

No influence of puberty or the prepubescent stage is clearly proven in any of the results.

The Maryland Mental Survey. The Report of the *Maryland Mental Hygiene Survey*, conducted by Dr. T. H. Harris and participated in by Miss Elizabeth Greene ('13) and Mina A. Sessions ('13), has just been published. A summary of findings is given in the table, which shows the percentage distribution in each institution of each diagnosis.

Diagnosis	Public Schools White	Public Schools Colored	Industrial "Schools"	Penitentiary etc.	County Almshouses
Superior	10.5	0.1	1.3	....	....
Normal	60.6	24.0	21.8	14.6	17.8
Dull Normal	11.4	38.2	24.6	28.3	1.6
Borderline def	3.5	4.6	5.3	10.9	0.6
Mental defect	2.5	8.9	8.5	11.8	24.2
Character def	9.1	16.3	19.4	9.2	0.3
Psychopath person	1.5	4.3	10.6	16.9	2.2
Psychneu. & neuros	0.3	3.3	7.5	5.3	0.3
Mental disease	0.3	....	0.5	2.9	50.0
Epilepsy	0.1	0.4	0.3	0.2	1.9
Others	0.1	....	0.2	....	1.0
Numbers	4,163	676	944	1,386	314

Striking results shown in the table are: The marked lower mental grade of colored as compared with white schools; the prevalence of "character defect" in training and industrial schools; the stupidity and the psychopathic personality of the penitentiary inmates; the insane and imbecile in the county almshouses.

Eugenical News, Feb. 1922, VII, No. 2, 11.

DEMOGRAPHY

Immigration. *Ann. Rep. Comm. Gen. of Immig.* for the year ending June 30, 1921. U. S. Dept. of Labor, Wash., 1921.

The report gives the usual annual statistics on immigration to the United States. The total number of immigrants admitted during the fiscal year 1920-21 was 805,228, or nearly twice as many as the year previous; but 247,718 persons emigrated back to Europe. By far the greatest number (222,260) came from Italy, the countries most represented after that being Poland (95,089), Great Britain and Ireland (79,577), Czechoslovakia (40,884), Greece (28,502), Rumania (25,817), Spain and dependencies (23,818) and Jugoslavia (23,536).

Beginning with 1921-2 under the new law, the number of aliens admissible from the principal countries will be as follows:

Austria	7,444	Netherlands	3,602
Belgium	1,557	Norway	12,116
Bulgaria	301	Poland	20,019
Czechoslovakia	14,269	Eastern Galicia	5,781
Denmark	5,644	Portugal	2,269
Finland	3,890	Rumania	7,414
France	5,692	(Russia including Siberia)	34,247
Germany	68,039	Spain	663
Greece	3,286	Sweden	19,956
Hungary	5,635	Switzerland	3,745
Italy	42,021	United Kingdom	77,206
Jugoslavia	6,405	Armenia	1,588

Birth Rates in the United States, 1920. The Department of Commerce, through the Bureau of the Census, announces that in the year 1920 there were 1,508,874 births reported within the birth registration area of the United States, which includes 23 states and the District of Columbia, the estimated population of this area on July 1, 1920, being 63,659,441 or 59.8 per cent of the total poulation of the United States. The birth rate was 23.5 per 1000 of white population, which is considerably higher than the rate 22.3 for the previous year, but is below the rate (25) for 1916, which may be looked upon as a more normal year, as it preceded the influenza epidemic and the entrance of the United States into the war.

For 1920 the highest birthrate (31.7) for the white population is found for North Carolina and the lowest (18.3) for California, while for the colored (which includes Negroes, Indians, Chinese and Japanese) the highest rates are 39.5 and 39.3 respectively, for Washington and California. The next highest rate for the colored (31.3) is for North Carolina. The lowest rate for the colored (disregarding the very low rates

in a few of the New England States in which the Negro population is small) are for Kansas (17.1) and Kentucky (17.6).

Pub. Health Reports, Wash., Dec. 23, 1921, 3142.

The American Negro. The census records for 1920 show that during the decennial period from 1910 to 1920, the American negro increased 6.5. per cent, whereas his increase in the preceding decade from 1900 to 1910 was 11.2 per cent., but the most striking feature of the negro census returns is his redistribution. With the advent of the World War and the shutting off of European immigration, the demand of the North and the West for unskilled labor was supplied largely by the northward and westward inter-state migration of negroes. Thus during the decade just ended, the negroes in the South increased only 1.9 per cent., in the North 43.3 per cent., in the West 55.1 per cent.

Eugenical News, Vol. VI, Nos. 11–12, 73.

Small Increase in the Colored Population

The colored population of the United States increased at a lesser rate during the last decade than ever before. The increase was only 6.5 per cent during the last ten years. As the rate of increase in this race has declined during the last three decades, the question may be asked how soon the colored population will reach a point where there is no increase at all. As there is very little emigration or immigration of the colored people, the condition of the population increase depends entirely on the relation of the birth to the death rate. We have been in the habit of looking upon the colored people as a highly fecund race and this was undoubtedly true during the slavery period and for several decades thereafter. Today thay are not far from the point where the number of their births and deaths will be about identical. What has caused this change in the situation?

Unfortunately, we do not have all of the facts to give a complete answer. Birth registration among the colored people is far from good, and such figures as we have cover only very recent years. Yet, such as they are, they show very clearly a marked decline in the birth rate. This tendency is also evident to be sure, among the whites, but there is as yet no very marked decline in their rate of natural increase. This is because the decline in the birth rate among the whites has been compensated by a very marked decline in the death-rate. While birth rate among the colored is now about the same as among the whites the death rate is very much higher. In fact, in many areas it is twice as high. Perhaps the most unfortunate tendency from the standpoint of race increase which is manifested among the colored people is their crowding into cities where conditions apparently are very adverse to their multiplication. In 1919 the ratio of births to deaths among the colored people in the cities was 104 to 100, whereas in the rural part of the registration area it was 159.

The evidence is very clear that what the colored people need more than anything else for their racial preservation is the development of good public health work among them. Their death rate for tuberculosis

of the lungs is about twice as high as among whites; among their adolescent boys and girls it is about ten times as high as among whites of the same ages. The high infant mortality rate among the colored strikes deep at their rate of increase. Such conditions as malaria, typhoid fever and hookworm infection are still very prevalent in the South, where they live. The devastating disease, syphilis, is doing enormous mischief among the colored people, as shown by the high proportions of positive reactions among colored women in maternity clinics, and the high mortality of the newborn infants from the congenital causes. It may well be that this condition also explains the high prevalence of the other chronic affections among them, especially of heart disease. In any case, whether or not this is the explanation, the colored people suffer a great deal more than do whites from the chronic organic diseases. There is also to be remembered the very great waste of life among negroes from homicide. Among negro males between the ages of fifteen and thirty-five years, the homicide rate is approximately ten times that of whites.

There were in the United States 10,463,013 colored people in 1920, who, for their own sake and for the welfare of their white neighbors, should be given a greater measure of public health instruction and service than they now enjoy. This will prove to be the most valuable service that can be rendered them at this time.

Stat. Bull., Metrop. Life Ins. Co., July, 1921.

Vital Statistics, England and Wales, 1920

The following statements are taken from the "Quarterly Return of Marriages, Births and Deaths Registered in England and Wales" (No. 288), issued by the Registrar General. The figures given are provisional and may differ slightly from revised figures to be presented later.

> "According to the quarterly returns furnished by local registrars, 957,994 births and 466,213 deaths were registered in England and Wales in the year 1920. The natural increase of population, by excess of births over deaths was therefore, 591,781, the average annual increase in the preceding five years having been 187,625. This statement excludes all war deaths except those registered in this country. The number of persons married during the year was 759,316.
>
> "The numbers of births and of marriages are the highest ever recorded, while the number of deaths is the lowest since 1862, when the population was only about 20,000,000. Natural increase also was the greatest on record.
>
> "The marriage rate in England and Wales during the year 1920 was 20.1 per 1,000 of the estimated population in the middle of the year, the birth rate 25.4 per 1,000 and the death rate 12.4 per 1,000. Infant mortality was 80 per 1,000 registered births. The marriage rate was higher and the total death rate and infant mortality lower than in any other year on record. The birth rate was the highest since 1909."

Vital Statistics, England and Wales, 1920

	Number	Per 1,000 population
Population	37,610,000	...
Marriages	379,658	...
Births	957,994	25.4
Deaths:		
Total	466,213	12.4
Infants under 1 year of age	76,736	80.2
Persons aged 65 years and upward	156,821	...

Public Health Reports.

Statistics relating to the growth of the population of *France* show that last year the excess of births over deaths was 159,790, as against 58,914 in 1913, while the number of marriages has doubled. It is the first time since the war that statistics have been available for the whole of France including the three departments of Alsace-Lorraine. The births were 834,411 last year, compared with 790,355 in 1913—an increase of 44,056. The deaths were 674,621 against 731,441 in 1913—a decrease of 56,820. The marriages were 623,869 last year against 312,036 in 1913.

Science, Sept. 16, 1921, p. 247.

Vital Statistics for Germany, 1913-1920, Inclusive.—*Public Health Reports,* Washington, 1921, XXXVI, No. 35, 2125.

The accompanying table gives the marriage, birth and death rates in Germany, per 1,000 inhabitants, for the years 1913 to 1920, inclusive. The figures are taken from the Statistische Reichsamt and were furnished by the economist consul of the United States Department of Commerce.

The death rate rose considerably during the war, and in 1920 was still slightly above the rate for 1913. The birth rate fell during the war, and in 1917 it was only about 50 per cent of the rate for 1913. In 1920 it was still slightly below the 1913 rate. The marriage rate also fell during the war period, but in 1920 it was almost double that for 1913.

Marriage, birth and death rates in Germany, per thousand inhabitants, from 1913 to 1920 inclusive.

	1913	1914	1915	1916	1917	1918	1919	1920
Marriage	7.7	6.8	4.1	4.1	4.7	5.4	13.4	14.8
Birth	28.5	27.6	21.0	15.7	14.4	14.7	20.6	27.1
Death	15.8	19.9	22.0	19.7	20.8	25.1	16.1	16.3

Hawaiian Census. The report of the Bureau of the Census on the population of Hawaii shows that in 1900, to 100 females there were 223.3 males. In 1910 this ratio had dropped to 178.9; in 1920 to 144.3. This preponderance of males is due largely to the influx of Porto Rican, Chinese and Japanese laborers. Among the native Hawaiians, the sex ratio in 1920 was 102.2 males to 100 females.

The Japanese in 1900 comprised 39.7 per cent of the whole population; in 1910, 41.5 per cent; in 1920, 42.7 per cent; while the pure Hawaiian stock declined 19.3 per cent in 1900 to 13.6 per cent in 1910, and 9.3 per cent in 1920. The Hawaiian hybrids increased from 5.1 per cent of the total population in 1900 to 6.5 per cent in 1910, and to 7 per cent in 1920. At the latter date Caucasian-Hawaiians comprised 4.3 per cent, and Asiatic-Hawaiians 2.7 per cent of the total population. Thus it is clear that the native Hawaiian race is being supplanted by Orientals and Caucasians. In 1920 the Caucasians of all types comprised 21.5 per cent of the total population. This was a decrease over the 22.8 per cent in 1910, which latter however, was an increase over the 18.7 per cent in 1900. Unless Caucasian immigration is encouraged, present tendencies unchecked will orientalize the whole territory of Hawaii.

Eugenical News, Vol. VI, Nos. 11–12, 73.

Life Expectancy of the Foreign-born in the United States

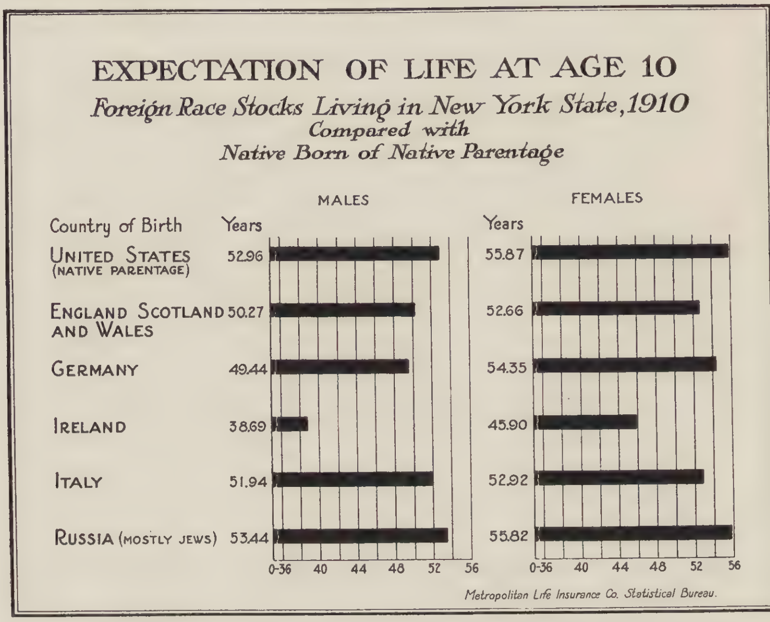
A study recently completed by the Company for the Second International Congress of Eugenics shows that among foreign race stocks living in New York State in 1910, the Russian-born have the highest expectation of life. In New York State, the members of this group are mostly Jews. Among males, at age 10, the expectation of life of the Russian-born was 53 years and among females, 56 years. This is practically the same expectation of life as that of the native-born of native parentage.

The least favorable expectation was recorded for the Irish-born. Among males of this group the expectation was only 39 years; among females 46 years. There is a difference therefore, of practically 14 years for males, and of 10 years for females, between the expected after-life-time of the Irish- and Russian-born populations in New York State.

The Italian-born, like the Russians, show favorable expectations. Males at age 10 had an expectation of 52 years; females, an expectation of 53 years. The British-born came next in order of favorable expected after-life-span. Among males of this group the expectation was 50 years, and among female 53 years. With the exception of the Irish-born, the German-born males showed the lowest expectation (49 years). German-born females, however, showed a better expectation of life (54 years) than any of the other foreign-born females, with the exception of Russians.

It is very important to observe that these foreign-born stocks living in New York State have, with the exception of the Russians and Italians, lower expectations of life at age 10 than are found in the populations of their native countries. It is difficult to understand why, for example, British-born males and females living in New York State should have a shorter life span by about 3 years than the population of England and Wales. Nor is it clear why German-born males should suffer a loss of nearly 2 years by living in this country. The undoubtedly better economic conditions which the foreign-born enjoy here are not sufficient, apparently, to offset the difficulties of adjustment of the newcomers to

American conditions. The figures emphasize the importance of concentrating health activities on foreign-born stocks living in the United States. The following chart illustrates the figures on the life expectancy of the foreign-born.



Stat. Bull., Met. Life Ins. Co., Sept. 1921, II, No. 9, 4–5.

THE BIOLOGY OF DEATH. By Pearl (Raymond)—*Sci. Monthly*, 1921, 7 parts, March-Sept.

A highly suggestive as well as instructive series of articles dealing respectively with: 1. The Problem; 2. Conditions of Cellular Immortality; 3. The Chances of Death; 4. The Causes of Death; 5. The Inheritance of Duration of Life in Man; 6. Experimental Studies on the Duration of Life; 7. Natural Death, Public Health, and the Population Problem.

Properly to abstract this ingenious work would require more space than can be given to it in this place; but the whole may well be recommended to all those who are dealing with or are interested in these problems.

A STATISTICAL METHOD OF TESTING THE BIOLOGICAL CAUSES UNDERLYING THE EXCESS OF MALE BIRTHS DUE TO THE WAR. By Huxley (J.S.)—*Eug. Rev.*, Jan., 1922, XIII, No. 4, 549-550.

In commenting on a recent article on the subject by Savorgnan (*Metron*, 1921, 1), the author gives the following data and conclusions:

"In England and Wales the proportion of males born alive to 1,000 females born alive was in the decade before the war 1039 (varying from 1036 to 1041 in different years); in 1915 it was 1040; in 1916, 1049; in 1917, 1044; in 1918, 1048; and in 1919 (in which the effects of the war on birth statistics were obviously still being felt), 1060. . . .

Savorgnan comes to the conclusion that the absence of a great mass of the male population from home increased the time between births; that this gave the embryos *in utero* a better chance of living; that since the number of males dying *in utero* or still-born is in man always much above that of females, the males are more delicate or else make more demands upon the mother, and that therefore the better conditions afforded by the longer period between births would reduce the number of early male deaths *in utero* so as to increase the proportion of male births. Thus the recorded increase of the proportion of males would be simply a question of altered viability. . . .

I would prefer the alternative hypothesis, namely that some zygotes which in normal conditions would have been females have been through war-conditions—whether these are nutritional or (more probably) dependent upon nerve strain acting through the sympathetic nervous system on the organism—converted into males."

If the latter assumption is correct, it ought to be reflected in a rise in the proportion of female births of twenty to forty years hence.

A Biological Classification of the Causes of Death. By Pearl (Raymond)—*Metron*, 1921, I, No. 3, 92-99.

The object of the author in proposing his classification is "to put together all those lethal entities which bring about death because of the functional breakdown of the same general organ system. . . In other words the basis of this classification is not that of pathological causation but it is rather that of functional, organic breakdown." The purpose of the classification "is purely analytical for the further study of certain problems of biology underlying human mortality statistics" and is not advocated for general statistical purposes.

HEREDITY EUGENICS

Human Heredity. By Redfield (Casper L.)—12mo. Chicago, (Hered. Publ. Co.), 107 pp.

A stimulatingly written little book, in which Mr. Redfield re-states, with collaterals, his conviction that the surest way to increase ability in the progeny is by a healthy but intensive exercise of that ability—be it muscular or mental—in the forerunners. In connection with and as a corollary of this, he believes that elder human parents, who have spent their lives in an intensive development of their intellectual faculties, tend to transmit greater mental abilities to their progeny than parents who, through youth or otherwise, have not so exercised their powers.

There is doubtless some truth, at least, in these views; but the whole subject is so large and complex that the adduced examples and statements alone do not fully satisfy. This is but one angle of the subject. But the author deserves credit for his perseverance against almost overwhelming difficulties, in rousing attention in this direction.

Eugenics in South America. By Harris (Reginald G.)—*Eug. News*, 1922, VII, No. 3, 17-42.

In a well written article the author considers the nature, status and effects of blood mixture in South America, reaching the following conclusions:

The characteristics and social inheritance of the peoples which entered early into the mixing of races in South America have been noted. It has been seen that the several races, white, Negro and Indian were not all at the same degree of development; that the Negro and Indian races have been drastically acted upon by lethal factors of natural selection. From various kinds of evidence, viz.: height of development in isolation, amount of contribution to the social inheritance of mankind, and finally, comparative response to racial competition, it is concluded that both the Indian and Negro races, are represented in South America, are inferior to the white race. In spite of this fact, no barriers to racial interbreeding, save the barrier of social class, are found existing commonly in South America. Consequently, race mixing has been going on almost unchecked since the earliest days of conquest and colonization. Nor, speaking generally, have the resulting hybrids been looked down upon by any of the pure blood parent stocks. The hybrids themselves have generally been of a type intermediate between the two parent stocks both physically and mentally. There have been some exceptions in both directions of development; some exceptionally brilliant, and some exceptionally stupid. In spite of this seeming intermediate position of the hybrids, they have failed to provide South America as a whole, with that which it seriously needs, namely, an active, intelligent middle class. Not only has the mixing of races failed to produce a satisfactory germinal complex in the resulting offspring, but the effect of the propinquity and crossing of races as an environmental factor has apparently been unfavorable to a normally full expression of the possibilities which the germinal complex may hold. Indeed anyone who is interested in rapid and permanent progress in South America, especially in those countries where the crossing between the races already mentioned has been great, and where the hybrid class, or the inferior race, is greater in number than the white race, must often despair of the realization of his hope. Eugenically, the crossing of widely different human races, viz., Indians, Negroes and whites, in South America, has not been successful, and its continuance is undesirable.

But in some countries of South America interbreeding of widely dissimilar races has not occurred. In these countries the need of rapidly increasing the population has been met by immigration rather than by hybridization with the native stock. It is significant that the nations in which immigration has been greatest exhibit to-day the highest national development to be found on the continent. Nor is the difference in natural environment between these and less developed nations sufficient to account for the disparity of national development. It is fair and logical to conclude that the differences of development are due to inequalities of germinal potentialities for development existing

among the several race of the nations. It has already been stated that race-crossing should be discontinued in South America. At the same time the hybrids should be replaced, and the general stock of Europeans renewed by abundant, selective immigration. In this way an active, intelligent middle class could be produced in the backward nations of South America, which would allow those nations to take their places with European countries of similar size and resources. A knowledge and practice of eugenics is necessary for the rapid development of those countries of South America where inferior races and hybrid stock are present in large numbers.

Race Decadence. By Sadler (Wm. S.)—12mo, Chicago, (A. C. McClurg & Co.), 1922, 421 pp.

The volume is essentially a popular medical and eugenic treatise in which the author endeavors to show that there is a great deal in the present conditions of the American people which calls for improvement. The lines are overdrawn in some respects and medical advice obtrudes in others; nevertheless the volume brings many facts which are not generally appreciated. From a scientific point of view the best parts of the book are the "summaries" (though they are really programs rather than summaries) of the various chapters, of which we may well quote the following:

"A better understanding of the basic race problems concerned in American society would contribute greatly to a better solution of our industrial and economic problems.

A more complete biologic knowledge of the laborer might greatly help the statesman and the sociologist in solving the labor problem.

Many of our political problems could be more intelligently handled and more permanently settled if our politicians had a better understanding of the real physical status of the American people.

Some of our social questions can be unraveled only by those who possess a working knowledge of modern hygiene on the one hand and heredity on the other.

The racial composition of the American people has a vital relation to the practical solution of numerous pressing industrial problems.

Immigration is directly related to a host of the acute and chronic social situations and industrial difficulties of the present time.

As a people we stand in need of a great spiritual awakening—a national revival—based on the facts and truths of biologic science.

Moral reforms must be based on the facts of human heredity and must take due cognizance of human nature if they are to succeed.

There is immediate need of more fully recognizing the nation's health problems and better organizing its health agencies.

The crying need of the hour is a complete system of "vital statistics" covering the entire country.

Race hygiene is the study which should take precedence of all other subjects in the minds of the American people.

Race is the fundamental determiner of citizenship. There are some white races which are just about as unfitted for American citizenship (in the first generation) as are the Orientals.

The remedy for our national ills will not be found in the mirage of socialism, or the quack cure-alls of fake reformers. We need more education and less agitation.

Blind national optimism, ignorant patriotism and the delusion of the melting-pot will not deliver us—we need the sound facts of biologic science to guide the nation in working out its social and political salvation."

The volume is the first of a series of proposed four volumes by the author: the three remaining to deal respectively with Genetics and Heredity, Race Betterment (Eugenics) and American Problems (Race Hygiene). There ought to be a fifth volume on "Race Regeneration."

A FURTHER NOTE ON WAR AND POPULATION. By Pearl (Raymond)—*Science*, 1921, LIII, No. 1362, 120-121.

Basing himself on recent demographic reports relating to the war period and to the late gread epidemic of influenza, the author shows that "the effects of the most destructive war known to modern man, and the most devastating epidemic since the Middle Ages, furnish a substantial demonstration of the fact that population growth is a highly self-regulated biological phenomenon. Those persons who see in war and pestilence any absolute solution of the world problem of population, as postulated by Malthus, are optimists indeed. As a matter of fact, all history definitely tells us, and recent history fairly shouts in its emphasis, that such events make the merest ephemeral flicker in the steady onward march of population growth."

LE REPEUPLEMENT DE LA FRANCE. By Stouman (Knud)—*Rev. Intern. d'Hyg. Publ.*, 1921, II, No. 4; repr. 8°, Genève, 1921, 28 pp. (with statist. data & demog. maps).

Author points out the necessity for France and Europe as a whole, of improvement in demographic conditions in France. He advocates, aside of all possible efforts towards an increase of natality, that attention be especially devoted towards decreasing the still high infant mortality, and in the second place towards reducing the prevalence of and mortality from tuberculosis.

RASSENMISCHUNG-VERMEHRTE HETEROZYGOTIE (GENCHAOS)—KONSTITUTIONSVERÄNDERUNGEN.—*Hereditas*, Lund, 1921, II, By Lundborg (H.) Transl. with illustr's *J. Hered.*, 1921, June-July, 274-280.

As a result of his observations in northern Sweden and elsewhere, the author discusses the apparent effects of intermixture of different physical and ethnic types and supports his views by a selection of portraits. Among the most conspicuous results of mixture he believes are increase in stature and narrowing of the face. He does not take account of other factors, especially food and mastication, which have an important bearing on the production of these same changes.

Infant Welfare Work in Europe. By McGill (Nettie)—*Child. Bur. Publ.* No. 76, Wash., 1921. 169 pp.

A valuable account of work and experiences in child welfare in Great Britain, Austria, Belgium, France, Germany and Italy during, and immediately after the period of the war. The importance of saving the life and health of the child for the nation is being fully recognized and acted upon among all the civilized peoples.

(Outline of our Knowledge of Heredity; in Czech). By Růžička (Vladislav)—Part I, small 8°, Prague, 1914, 342 pp. 60 illustr.

Received belated. A remarkably well documented, printed and illustrated work by the Director of the Institute of Biology and Experimental Morphology of the Czech University, a translation of which in English should be welcome. The book is too rich in details to be briefly reviewed, but deserves in full measure to be called to the attention of workers in heredity. Parts of particular interest to anthropology are those dealing with Variation and with Inheritance of Acquisitions.

Some Implications of the Chromosome Theory of Heredity. By Huxley (Julian S.)—*Sc. Progr.*, Oct, 1921, XVI, No. 62, 235–250.

"The older discussions of Genetics and Evolution were inevitably in large parts theoretical. It is the aim of experiment to make our formal explanations and theoretical generalisations more precise, by a discovery of the actual mechanisms involved, and so to pave the way for prophecy and control. The hypothesis of a gene-complex located in the chromosomes is the first-fruits of the twenty years' experimental breeding which followed the rediscovery of Mendel's laws. It is obviously the merest sketch of reality; in all probability it is erroneous in some respects. But it is at least the only hypothesis which allows us to synthesise so many distinct sets of facts in one conception. The Mendelian doctrines of unit-factors and segregation, the cytology of the chromosomes, their constancy of number, their individuality, their mitosis and reduction; the phenomena of linkage and crossing-over; the continuity of the germ-plasm; mutation; the variability of species on the one hand, their relative constancy on the other; the function of sexual fusion; the epigenetic course of development and the restoration of organic form-equilibrium; the hereditary effects observed by Guyer after injection of anti-lens serum; sex-linkage and the basis of sex-inheritance; the abnormalities of non-disjunction and of duplication,—all these can be blended harmoniously in the hypothesis which sees in the chromosomes the bearers of the hereditary constitution or organisms under the form of a definite structural complex of self-reproducing genes."

The discussion of the subject by the author and his pointing out of the many difficulties in the way of acceptance of any simple notion, are worth perusal by those interested in the problems of heredity.

THE INHERITANCE OF ACQUIRED CHARACTERS. By MacBride (E.W.) —*Science Progress*, Apr. 1921, 642–4.

In answer to criticism by J. S. Huxley (*ibid.*, 640-'1), Professor MacBride in this well written short communication, reasserts his belief that "mutations due to abnormalities of division appear to me to have played no part in the evolutionary process, which, there is every warrant for believing, must have been slow, functional and continuous."

Both Mr. Huxley and Professor MacBride return to the subject in *Sc. Progr.* of Oct. 1921, 292–303. These discussions are well worth perusal. See also further criticism in Prof. MacBride's "The Chromosome Theory of Inheritance," *Sc. Progr.*, Jan. 1922, 450–6.

INHERITANCE AND EDUCABILITY. By Tredgold (A.F.)—*Eug. Rev.*, 1921, XIII, No. 1, 339–350.

The degree of educability varies in different individuals, and is due to a potentiality for mental development which is innate. The realisation of this potentiality is dependent upon the stimulus of education and a favorable environment.

Minor variations in educability are probably but manifestations of a tendency to vary which is universal, and are not pathological.

A marked lessening of educability is probably pathological. It shows a tendency to run in families, and is best explained as due to an impairment of germ potentiality. This impairment results from the operation of devitalizing influences upon the germ plasm.

There is reason to think that provided the germ plasm is healthy, the exercise of mind, continued generation after generation, may give rise to an increased educability in the offspring. Previous life conditions may thus explain the differences in educability occurring in different races and sections of mankind.

Impairment of potentiality is a far more rapid process than augmentation. The former may take place in a few generations; the latter only occurs where the germ plasm is healthy, and many generations must elapse to produce any appreciable result. . . .

Nations cannot stand still. The law of the survival of the fit applies equally to them as to individuals, and they must either progress or retrogress. If a nation is to progress, it must develop and utilize to the full all its resources, and of these none are more important than the developmental potentiality of its citizens. . . The remedy lies in the revival of the aristocratic ideal; but not an aristocracy of rank or of wealth, an aristocracy in the true sense of the word, and consisting of all that is noble and capable in man, an ideal of the duty we owe to our children and to their posterity in preserving them free from any tainted admixture, an ideal of biological fitness and of being truly "well-born."

(INBREEDING. In Czech). By Kříženecký (J.)—*Eugen. Knih.*, I, 8°, Prague, 1919, 142 pp.

Probably the most thorough and up-to-date biological and anthropological treatise on the subject of human inbreeding through marriage

among relatives or otherwise. It is regrettable the work could not have been printed simultaneously in English, French or German. The very conscientious study of the subject in lower organisms as well as in man, leads the author to the conclusion that, under normal conditions, biology can adduce no general material objection against such unions. In human society, however, the factors of accepted usages and morality are of paramount importance and must be respected.

Appended to the book is an extensive bibliography.

THE DANGER OF DEGENERACY. By Lundborg (Herman)—*Eug. Rev.*, Jan. 1922, XIII, No. 4, 531-539.

A good eugenic article of a general nature. "The modern science of heredity and the still younger biological branches, race-biology and eugenics work diligently to investigate the natural laws which govern nations and races. Our knowledge increases incessantly. One is concerned in saving all that can be saved, so as to be able to build up a stronger and better race. With the statesmen, politicians and scientists leading the van every good citizen in every country ought, according to his powers to help in this work.

"One has a perfect right to entertain the firm conviction that a people, who learn in time to understand the importance of heredity and race, and who are willing at the same time to submit obediently to the natural laws that govern humanity, must advance triumphantly in the world not with the ravages caused by war, hunger and sickness in its track, but leading the way to a higher civilization, a wider and deeper morality and a happier human race. . . .

"Great race-biological institutes, well-equipped for the work of investigation must be established in all the civilized countries. The instinct of self-preservation will quite certainly compel this sooner or later."

RESEARCH IN EUGENICS (Address at the opening session of the II Intern. Congr. of Eugenics, N. Y. 1921). By Davenport (Charles B.)—*Science*, Oct. 28, 1921, 391-'7.

Respect for eugenic conclusions and procedure can only be commanded if these are based on rigid proofs. Only as Eugenists will be able to base their statements and advice on scientific data can they hope to carry conviction and meet with success. Human variation, heredity, genetics must be studied by best of methods. Most of these are specially mentioned.

The end of the paper is perhaps unduly alarmed and pessimistic. "The human species must eventually go the way of all species of which we have a paleontological record; already there are clear signs of a wide-spread deterioration in this most complex and unstable of all animal types. A failure to be influenced by the findings of the students of eugenics or a continuance in our present fatuous belief in the potency of money to cure racial evils will hasten the end. But if there be a serious support of research in eugenics and a willingness to be guided by clearly established facts in this field, the end of our species may long be postponed and the

race may be brought to higher levels of racial health, happiness and effectiveness."

Army Examinations and Heredity (ctd.) By Bramwell (B.S.)—*Eug. Rev.*, Jan. 1922, XIII, No. 4, 525-530.

Second article of a series badly lacking a summary and difficult to follow. It is based on the study of the records in school of 576 boys, and their subsequent behavior in the Great War. Barring some individual exceptions the records show that "the correspondence of the intellectual grade in early youth with performance as measured by military authorities in manhood is striking"; which naturally bears on heredity.

Some Disgenical Effects of the War in Italy. By Boldrini (Marcello)—*Soc. Hygiene,* July 1921, VII, No. 3, 265-278.

"The war . . . in Italy as elsewhere and in certain respects more gravely, brought out two groups of harmful effects, striking both in number and quality those who are universally known as 'war infants' [children born during the war] and threatening the physical and psychical constitution of a large number of adults who will be the parents of a generation of 'peace infants".'

The direct and indirect war losses amounted to near 2,000,000 (army 428,000; excess of deaths, decrease of births, 1,388,000).

ANTHROPOLOGICAL PROBLEMS PECULIAR TO THE UNITED STATES

Variation in the Rate of Infant Mortality in the United States Birth Registration Area—By Pearl (Raymond), *Trans. XI Ann. Meet. Am. Chil. Hyg. Ass.*, 1920.

Biometric Data on Infant Mortality in the United States Birth Registration Area, 1915-1918. By Pearl (Raymond)—*Am. J. Hyg.*, July, 1921, I, No. 4, 419-439.

Infant mortality rates exhibit a relatively high degree of place variation in both rural and urban areas of the United States. This high variation is evident upon any and every basis of estimation which may be chosen, whether range, standard deviation, or coefficient of variation.

This great variation demonstrates the opportunity which still exists for effective administrative control and reduction of infant mortality.

The distributions of place variation in infant mortality are unimodal for both urban and rural, white and colored populations.

There was no certainly significant decline in the mean or average rate of infant mortality in the United States Birth Registration Area during the years 1915-18, inclusive.

Presumably as a result of the influenza epidemic the mean infant mortality rates were higher (in some cases significantly so) in 1918 than in 1917 in cities. No such difference is exhibited by the mean rates for rural areas.

There is no significant difference in the mean infant mortality rates in large cities (over 25,000 population) as compared with small cities (under 25,000 population) in the United States Birth Registration Area.

The mean rates of infant mortality are notably smaller in the rural than in the urban areas, in both the white and the negro elements of the population.

The mean rates of infant mortality are something like twice as high for the colored population as for the white population in each of the demographic units considered (large cities, small cities, rural areas), and at all times.

Cities of over 25,000 population in the Birth Registration Area exhibit distinctly less variation in respect of rate of infant mortality than do either the smaller cities or the rural counties.

The colored population exhibits a much higher degree of variation, however measured, in respect of infant mortality than does the white population.

The Vitality of the Peoples of America. By Pearl (Raymond)—*Am. J. Hyg.*, 1921, I, Nos. 5 and 6, 592-674.

It is shown that the population of the United States is growing according to a definite curve, has passed the point of inflection of this curve and is rapidly approaching its asymptote.

The problem of the future is the *quality* of the asymptotic population. To estimate this from past conditions is one of the purposes of this paper.

It is shown that there are three general criteria by which the biological attributes of a population may be estimated or measured. These are: (1) somatic physical, (2) somatic psychological and (3) biostatical. These are defined and discussed. This paper deals solely with the third of these criteria, including marriages, divorces, births, deaths, and the birth/death ratio.

Racial assortative mating in marriages effective in producing offspring in 1919 is discussed.

For the entire B. R. A. the percentage of amalgamation or fusion of foreign born stocks with native-born as compared with racially like effective matings of all sorts, as indicated by effective marriages in 1919, is just under 11.5 per cent.

The amount of racial amalgamation or fusion going on in the several states of the Registration Area is proportional in the most direct and close way to the amount of foreign-born white stock in the local population.

The same result holds if the percentage of fusion matings of foreign with native stock is taken upon the base of pure native matings, instead of all pure matings as before.

In 10 out of 23 states there are *more* effective mixed matings of the amalgamating type (i. e. foreign × native) than there are of racially true foreign × foreign matings.

In the three states of Massachusetts, New York and Connecticut, there were in 1919 as many or more matings of the type of foreign-born x foreign-born as there were of the type native-born × native-born, *effective in producing offspring*. In these three states as large or larger additions to the future population were made in 1919 by the foreign-

born as by the native-born. Further, in three other states, New Hampshire, Pennsylvania and Maine, the effective foreign × foreign matings were more than half as numerous as the effective native × native.

The foreigner in this country is much more apt to marry an American-born person, if he does not marry one of his own race, than he is to marry some other foreigner not of his own race.

In 1919, there were in B. R. A. 78 racially different types of mating effective in producing offspring, not separating sexes of either mated partners or offspring. Sixty-five per cent of the births were from native × native matings, 10 per cent of the children had one parent native-born and the other foreign-born, leaving approximately 25 per cent of the births having both parents foreign-born.

In those parts of the country where a relatively large proportion of the population is foreign-born, the fertility of the foreign-born women is greatly in excess of that of the native born. Almost, if not quite, the first biological result of Americanization is to reduce the fertility of marriages.

The illegitimate rate is higher per 1000 foreign-born women capable of having an illegitimate baby than it is per 1000 native-born women in the same social situation. But per 1000 total births the illegitimate rate is smaller for foreign- than for native-born mothers. The explanation of this apparent paradox is given.

The stillbirth rate is higher, on the basis of total live births, for foreign—than for American-born women in general. In the case of Scandinavian, German, Polish, and Hungarian mothers, the stillbirth rate is lower than for native-born mothers.

After infancy and early childhood the age- and sex-specific death rates are lower at all ages for native-born of native parents than for either native-born of foreign parents or foreign-born. A detailed discussion of mortality and race stock is presented.

The biological vigor as indicated by the vital index (100 births/deaths) of the native-born population is much lower than that of the foreign-born population. In the New England States (except Vermont) and New York, the native population is not reproducing itself, and in Vermont only barely so.

The native population has a lower vital index in cities than in rural districts; the foreign population shows the reverse relation, the higher index being for the city population.

A study of age-specific vital indices for women shows that as a reproductive machine the foreign-born woman far excels the native-born. For each native-born women dying between 20 and 24 years of age, the native-born women as a group produce approximately 22 babies. The corresponding figure for foreign-born women is 35.

The peak value of the vital index for women falls in the age group 20 to 24 inclusive. For men the peak value is in the period 25 to 29.

Age and sex corrected vital indices are discussed.

Rural populations were slightly, but probably not significantly, less damaged, relatively in a biological sense, than urban populations by the

influenza pandemic. The foreign population was definitely harder hit biologically by the pandemic than the native.

Except in the rural districts of the southern states practically never does the vital index of a negro population rise to a value of as much as 100. Nowhere in cities, even in southern cities, does the value of the negro vital index get to 100.

Biologically the negro population of the B. R. A. was distinctly less severely damaged by the influenza epidemic than the white population.

A Genetic Portrait Chart. By Fairchild (David)—*J. Hered.*, 1921, XII, No. 5, 213-219.

Dr. Fairchild publishes herewith the portraits of three and several of those of the fourth generation of his family together with those of his three children. The high foreheads and narrow faces of the children are remarkable. The American Genetic Association, at whose urging these interesting portraits have been made public, is taking active steps to interest people in studies of their heredity.

THE AMERICAN INDIAN

Bibliographie Américaniste. By Rivet (P.)—*J. Soc. Américaniste.* Paris, 1920, XII, 287-331.

Le Mouvement Américaniste de 1914 à 1920. By Rivet (P.)—*Rev. d'Ethnog.*, 1920, No. 4, repr. 11 pp.

Continuations of the author's meritorious work in making known to the French and French reading men of science the publications and nature of work in the various branches of American anthropology.

The "Blond" Eskimos. By Jenness (Diamond)—*Am. Anthropologist,* XXIII, No. 3, 266, '7.

Some years ago Mr. Stefánsson, an Arctic explorer, announced the discovery of "blond" Eskimos in Victoria Island, and suggested that here in this remote corner of the Arctic we might find traces of the old Norse settlers who disappeared from Greenland in the course of the XV century. Basing himself on a two-year contact and extended personal studies of the Victoria Island and neighboring Eskimo, Dr. Jenness has reached some very different conclusions, which he sums up as follows:

"It seems clear that neither the color of the eyes, nor the color and shape of the hair, nor again the complexion of the Copper Eskimos, differentiates them in any way from the other branches of their race, or lends any support to the theory of Scandinavian or even European admixture. If such an admixture had occurred we should expect to find its signs, not only in these more external features, but also in the stature and in the shape of the head. Mr. Stefánsson's own comparison—breath of face with breadth of head—is inconclusive, firstly because he has insufficient data of a similar nature from other Eskimo sources with which to compare his data from the Copper Eskimos, and, secondly, because it is not recognized by the best authorities as a consideration of major im-

portance in determining questions of race. The principal feature that is employed for this purpose, the cephalic index, tends to show that the Copper Eskimos are as pure as the purest known branch of the Eskimo race of whom we have definite and detailed knowledge. Until therefore, we are presented with more tangible and significant evidence, the theory of Scandinavian or even European infusion among the Copper Eskimos, must be regarded as unproved, and indeed groundless."

The Life of the Copper Eskimos. By Jenness (D.)—*Rep. Canad. Arct. Exped.* 1913-18, Ottawa, 1922, XII, 277 pp., 2 maps, 9 pl., 69 fig.

This valuable report, while wholly of ethnological nature, includes chapters on Distribution of Population, Food, Mode of Life, Childbirth, Sickness and Death, which are of interest to Physical Anthropology. The many photographs, though printed in text, should also be mentioned in this connection.

Indian Village Site and Cemetery near Madisonville, Ohio. By Hooton (Ernest A.); with Archeological Notes by Chas. C. Willoughby.—*Papers Peabody Mus.*, Cambridge, 1920, VIII, No. 1, 137 pp. numerous illustrations.

Pages 83-137 of this detailed valuable report are devoted by Dr. Hooton to "The Skeletal Remains." The study extends to 84 crania and the bones of 112 skeletons, in addition to which the author draws on as yet unpublished data on a large collection of Tennessee crania in the Peabody Museum. The mode of presentation of the data is clear, sound, efficacious; and it is supplemented by five good plates showing types of the skulls.

The report gives us the following conclusions:

"The characters of the Madisonville crania examined have been summarized above in some detail. In general they are three-fourths brachycephalic and the rest mesocephalic, with the exception of two dolichocephalic specimens. The height of the skull vault is somewhat low, but the cranial capacity is well up to the average for Indians. The faces are broad and very short, the orbits low and broad, the nasal apertures prevailingly platyrrhine, with poorly developed nasal spine and indistinct lower borders. There is little prognathism and the jaws are short and broad. The mandibles are somewhat deficient in symphyseal height.

The femora indicate a stature of about 167 cm. for males and 155 cm. for females, which is a little above average for Indians but not tall. The long bones do not indicate especially pronounced muscular development, but about average for Indians. The limb proportions approximate to those generally observed in American Indians. Platymeria and platycnemia are not pronounced except in individual cases.

The Madisonville crania are less strong and rugged than those of the Tennessee Stone Grave group and differ from them in many respects, but particularly in lessened height of the cranial vault, of the face and of the mandible, in our series. The Tennessee group also contains a

large majority of brachycephals. There is little doubt that the Madisonville site was inhabited by a people in whom a preponderance of physical characters belonging to the southern and eastern brachycephalic group of Indians was united with an admixture of modified characters originating in the eastern dolichocephalic group. This group seems to have been the result of long contact rather than a primary mixture. Probably its physical affinities with groups, as yet unstudied, in Ohio and Indiana, are closer than with the Tennessee Stone Grave group or with the Iroquois and other eastern groups.

For many interesting details on the various skeletal parts the reader must be referred to the original.

We need more work of this nature.

Cuba Before Columbus. By Harrington (M.R.)—2 vol., 12mo., *Indian Notes & Monographs*, Mus. Am. Ind. Heye Found., N.Y., 1292 pp.

The best account to date of the archeology of Cuba. Includes many notes of interest to physical anthropology on burials, caves, skeletal remains and the former native population of the island. Distinguishes two separate peoples, the earlier Ciboneys of uncertain origin, and the later Taino, immigrants from Haiti and of Arawak derivation.

La deformación artificial del cráneo en los antiguos aborigenes de Colombia. By Montoya y Flórez (J.B.—8°, Medellin (Col.), 1921, 19 pp.

Very general. Based on a case of plagiocephaly, which author inclines to believe to be of hereditary origin due to artificial deformations in family, in a mestizo woman.

Demografia Salvadoreña. By Fonseca (Pedro S.) With Preface by J. Lardé—Small 8°, San Salvador, 1921, 48 pp.

Before the XI century A.D., the territory that is now San Salvador was occupied entirely by tribes of Maya derivation. In the XI century came the Nahua Pipiles and established themselves over the whole western and central part of San Salvador. The present population is still partly Indian, but in the main a mixture of the two Indian strains with the Spaniards, some negroes and a few Asiatics.

The total population to-day of San Salvador is approximately 1,500,000. Just how many of these are Indians, mixed or others is not known. There is a high birthrate (40.9) with a moderate deathrate (24.5). Male to female births are as 104 to 100. No less than 53.6 per cent of the births (mean of 22 years) are illegitimate and the proportion is steadily growing (in 1920—58.7 per cent). The maximum of births takes place in January, the minimum in June. Marriages, steadily diminishing, have reached in 1920 only 2.9 per 1000 inhabitants. Mortality of infants up to 1 year of age amounts to 145 per thousand yearly.

Los Indígenas del Ecuador. By Santa-Cruz (J.)—*Bol. Ac. Nac. Hist.*, Quito, 1921, II, No. 3-4, 17-32.

Anthropology in South America is not in a sound state. It lacks in precision and especially in rigid criticism. With Argentina still trying

in part to reset the crumbled idol of man's antiquity in that region, it is now Chile that seems to be endeavoring to forge ahead in a similar unenviable direction. The author, a Chilean, following others, assumes with the utmost facility an American paleolithic man corresponding to the early man of Europe, and fills the space between this and the historic Indian by steadily progressing imaginary groups. Small wonder that he declines to "enter into comprobations."

As to late prehistoric and historic Indians, the author appears to be on firmer ground, though again we miss material evidence. In his opinion these natives were largely of Arawak derivation, but those of the coast represented remnants and a mixture of various migrants or invaders. The three principal families of Ecuadorean Indians were the Guancas, Caras and Cañaris. The Inca Indians were descendants of those of Ecuador.

On a Series of Ancient Eskimo Skulls from Greenland. By Le Gros Clark (W. E.)—*J. R. Anthrop. Inst.*, 1920, L, 281-298.

The present communication was intended primarily as a report on a series of ancient Eskimo skulls in the possession of the anatomical department of St. Thomas' Hospital Medical School, in order to supplement our knowledge on the subject of Eskimo craniology. It will be seen however that the author has extended the original field of inquiry by taking the opportunity of constructing a "type contour" of the Eskimo skull; by briefly summarising the data culled from other reports on Eskimo skulls; and by using the information thus obtained for a detailed examination of the reported Eskimo characteristics exhibited by certain human remains dating from the Magdalenian phase of the Palaeolithic period.

The contours, constructed by the Parsons' method (*J. Anat. and Phys.*, 1910, XLIV, 396) include those of the frontal, lateral and superior normas of the skull with that of the palate and lower jaw. Comparing the average contours of the Eskimo with those of the Chancelade skull, which has so often been represented as Eskimo-like, he reaches the following sound conclusions:

"The conclusion to be drawn from this comparison must be of a negative nature. The Chancelade skull certainly presents some remarkable Eskimo characteristics. These however, are more than balanced by a number of features which are unusual in Eskimo skulls. It must therefore be conceded that there is no justification for the assertion that l'Homme de Chancelade" is a representative of an Eskimo population which lived in France during the late Palaeolithic Period."

But fallacies die hard, and the idea of the Eskimo in Europe will doubtless for a long time yet keep on recurring and clouding the issues.

Le Diprothomo d'après Schwalbe et d'après moi. By Ameghino (Florentino)—*An. Mus. Nac.*, Buenos Aires, 1921, XXXI, 1-24.

A. J. Torcelli publishes herein a series of fragmentary notes found in the papers of F. Ameghino and relating to Schwalbe's criticism of his

"Diprothomo." It is a question if F. A. would have approved of this publication. The notes are for the most part very imperfect and involved, show nothing new, and do not in the least tend to help the lost cause.

An Ancient Skeleton Discovered in Ecuador. By Saville (Marshall H.)—*Science*, 1921, LIV, No. 1390, 147-'8.

Mr. Saville describes an interesting find of a human skeleton in Ecuador. The skeleton was found in alluvial deposits "under conditions which indicate considerable antiquity." The find "was made in the province of Esmeraldas, along the beach at a place 40 miles north of the equator called Tomsupa. . . .The region here is a plain bounded on the north by low hills which terminate at the sea in a point called Punta Chevele. To the south just below where the Atacames River empties into the sea there are also hills, and at the ocean is a rocky point called Punta Sua. From appearances it would seem that this plain, three or four miles wide, was formerly the dwelling place of numerous people, as we not only find here the Tomsupa deposits, but they are even more extensive at the southern limit along the banks of the Atacames River, and they also extend inland for some distance. It would seem that this plain later became the course of a great river, which gradually deposited gravel and alluvium to a depth of fifteen feet. Then came a washing away of the alluvium, more extensive to the south, as at present more than half of the plain along the beach is only slightly above high water mark. . . .

"Near the northern extremity of the plain is a ridge of alluvium running at right angles to the beach, which abruptly terminates at the north toward Punta Chevele, and from here on to the point the same conditions prevail as at Atacames, the plain being only slightly above high water mark. In this alluvial ridge there is a layer of stratified coarse gravel 12 feet from the surface, and this deposit extends southward for several hundred yards terminating with a covering of alluvium of three or four feet. This gravel deposit averages 2½ feet in thickness.

"The skeleton to which attention is called in this communication was discovered at the deepest part of the ridge and under the gravel, being covered by 12 feet of alluvium and 2½ feet of gravel." It proved to be the skeleton "of a young man just cutting his wisdom teeth with the arms and legs bent close to the body, and the skull had been deformed with the frontal depression. The entire skeleton was tinged a bright red by the infiltration of iron, and the inner surface of the skull was covered by a deposit of brownish-black limonite. We were able to take out the skull, which fell into a hundred pieces, and only fragments of the bones. The only relic found was the foot of a pottery vessel, with traces of a highly polished red inner surface. This was found near the skeleton above the bones and under the gravel.

The skeleton was covered with earth immediately below the layer of gravel and alluvium, and was not intrusive, there being absolutely no signs of disturbance above. It could not have been intruded from the

side as there is rapid erosion going on here. Every year parts of the banks are washed away by the sea during the time of flood tides. The owner of the property assured the writer that the bank now visible is not the surface seen during former visits, as the ocean is slowly washing away the shoreline.

"Concerning the age of this skeleton, the archeologist is not competent to pass his opinion. This must be done by the geologist and physiographer. But the writer is of the opinion that this find is the oldest burial thus far found in South America."

In discussing the find with the reviewer a short time after the publication above, Mr. Saville disclaimed intimating any geological age to the bones; but he believes they may be at least two thousand years old, in which case they would in fact represent perhaps the most ancient American burial yet discovered.

The Stone of the Sun and the First Chapter of the History of Mexico. By Palacios (Enrique J.)—Transl. by Fred. Starr. 8° *Univ. of Chicago Press,* 1921, 77 pp.

In an ingenious way the author deciphers the dates on the well-known Aztec Calendar Stone in Mexico, arriving at the following conclusions of interest to physical anthropology:

The Toltec race had a definite reality. The people known by this name arrived in the Mexican Valley about the year 596 A. D.

"Toward the year 700 the Toltecs were organized and elected a monarch establishing themselves in a city to which they gave the name of another older one where they had lived in earlier times. . . .

"In the year 1064 the tribe of the Aztecs, also of Nahua race, undertook a pilgrimage, going out from a place the exact location of which is not yet known; it is nevertheless a fact—the codices state it—that the Aztecs began their journey in watercraft.

"In 1227 they arrive at Chapultepec and in 1247 kindle the new fire in that place. Their chronological system is the same as that of the Toltecs; the cycles of 52 years show it.

"In 1323 they definitely found the city of Tenochtitlan. . . ."

ABNORMAL CLASSES. COMPARATIVE PATHOLOGY. TERATOLOGY

Organic Dependence and Disease: Their Origin and Significance. By Clarke (John M.)—8°. *Yale Univ. Press,* 1921, 113 pp., 105 fig.

From a paleontological standpoint, and in a well-documented way, the author traces the origin and biological meaning of disease. In his own words the purpose of his "essay is to set forth a basis of fact and reasonable inference bearing on the comprehension of the control which governs the historical origin of dependent and abnormal conditions in the living world." He explains the phenomena of symbiosis, mutualism and parasitism and follows their development as well as effects. The scope of the study will best be appreciated from the contents, which are: What is

Disease? What is Normal Living? The Meaning of Abnormal Living; Protective Covering a Basic Factor in Dependence; Stabilization; Longevity and Dissolution; Divisions of Geological History; Independence of the First Fauna; General Survey of the Cambrian Fauna of North America; The Cambrian Fauna Generally; Precambrian Life; The Beginnings of Symbiosis and Parasitism; Illustrations of Primitive Parasitism; The Distinction between Protozoan and Metazoan Parasitism.

PHYSICAL EXAMINATION OF THE FIRST MILLION DRAFT RECRUITS: METHODS AND RESULTS. By Love (Albert G.) and Chas. B. Davenport. *Bull. 11, Med. Dept. U. S. Army*, 8°, Wash., 1919, 521 pp.

The title of this report may prove somewhat misleading—it deals only with the medical examinations and not with anthropometry. Many of the items would nevertheless be of interest to physical anthropology were it not for the fact that they do not relate to the drafted men, but only to those who had been sent to the mobilization camps, where they were re-examined. "The defects thus recorded, distributed by States and by rural and urban districts, have been made the subject of analysis in the Medical Records Section of the Surgeon General's Office. The results of this examination of the first million men are given in the accompanying report."

It is hard to see just what use can be made of the data.

NATIONAL HEALTH IN THE LIFE INSURANCE MIRROR. By Cox (Robert L.).

In an address delivered at the Fifteenth Annual Meeting of the Association of Life Insurance Presidents at New York, December 8, 1921, Mr. Cox, third Vice-President of the Metropolitan Insurance Co., states as follows:

> "The striking thing shown by these figures, covering 27,000,000 human lives, which of necessity reflect general health conditions throughout the country, is the extraordinarily favorable mortality of the current year in comparison with the year 1920—a year which up to that time was one of the best which life insurance companies had ever experienced. These figures for ten months of 1921, supplemented by what we know of our mortality experience as it has been running since October 31st, show that the United States and Canada as a whole will close the year 1921 with a lower death rate than has ever been experienced by these countries in any calendar year of their history."

The diseases that showed increased death rate were cancer, scarlet fever and diphtheria.

QUANTITATIVE STUDY OF THE VIGOR OF THE RACIAL ELEMENTS IN THE POPULATION OF THE UNITED STATES. By Dublin (Louis I.)—*Scientif. Monthly*, Jan. 1922, 93–103.

The several races that make up the foreign born population of New York are variable as to their natural vigor as measured by their mortality

rates or by life tables. With the exception of the Russians, who are for the most part Jews, the expectation of life of the foreign born is less than for the native born of native parentage. Of the foreign born, Russians have the best expectation followed in order by the Italians, the English, Scotch and Welsh, the Germans and the Irish. The last have a particularly low expectation. With the exception of the Russians and Italians the mortality is higher among these races living in New York State than in their native country. This condition may be due to the difficulties of adjustment to new conditions of life; or to the poorer quality of the immigrants as compared with their own people who stay at home, or to a combination of both these factors.

Death Rates of Infants in New York According to Race. From "Infant Mortality in New York City" by Meyer (E. Ch.)—*Bull. 10, Internat. Health Board,* Rockefeller Found., small 8°, N.Y., 1921, 135 pp.

The Influence of Race on the Infant-Mortality Rate of New York City in the Years 1916 and 1917[1]

Nativity of Both Parents	Births 1916	Births 1917	Death Rates (of deaths under per 1000 Births 1 yr. of age) 1916	Death Rates 1917
Ireland	4,662	4,752	114.5	112.6
United States	37,590	37,555	105.7	110.9
Germany	1,764	1,704	108.8	99.8
France	82	85	97.5	105.9
Italy	29,011	28,989	100.6	91.8
Sweden	463	567	99.4	72.3
Austria-Hungary	10,613	10,377	92.4	74.6
England	443	(?)	99.3	(?)
Bohemia	225	246	93.3	65.
Scotland	191	158	68.1	82.3
Russia-Polland (largely Jews)	23,016	24,099	75.3	63.6

Tuberculosis is Increasing among Adolescent Girls. Despite the very pronounced decline in the mortality from tuberculosis which has taken place during the last decade, the disease is actually increasing among girls between the ages of fifteen and twenty years. This is shown clearly by figures compiled by the Metropolitan Life Insurance Company which relate to the ten-year period 1911 to 1920. Adolescent girls constitute the only group in which the tuberculosis death rate has not declined.

The Company's compilations show that during the six-year period 1911 to 1916, the average annual death rate from tuberculosis among white girls aged 15 to 19 years and insured in its Industrial Department was 144.5 per 100,000; by 1919, this rate had increased slightly (to 145.8), and in 1920 it rose further to 151.5. These increases, it is true, are small; ordinarily they would not be commented upon. They become very

[1] No reports containing similar statistics were published by the Department of Health of New York City after 1917.

important and significant however, by virtue of the strong contrast which they present to the trend of tuberculosis mortality among both females and males of other age groups. For example, women from 20 to 24 years had an average death rate from tuberculosis of 238.0 per 100,000 during the six-year period 1911 to 1916; by 1919 this had decreased to 228.4; in 1920 there was a further and very substantial drop to 213.8. For insured white women aged 25 to 34 years a death rate of 252.2 was recorded for the six-year period 1911-1916; by 1919, the figure had declined to 214.3 and in 1920 there was a further drop to 190.5.

During the same time that the tuberculosis death rate of adolescent white girls was increasing 5 per cent, the mortality among adolescent white boys was decreasing 25 per cent.

Statistical Bulletin, Metropolitan Life Ins. Co., Vol. II, No. 12, 3, 4.

The Real Risk-Rate of Death to Mothers from Causes Connected with Childbirth. By Howard (William Travis, Jr.)—*Am. J. Hyg.*, March 1921, I, No. 2.(repr. 8°, 37 pp.).

"By using the sum of the living and still births reported and the number of the deaths of women from causes connected with the puerperal state, rates are calculated expressing the actual risk of dying for women exposed to childbirth with a fair degree of specificity and much more accurately than those obtained by the methods in common use.

When this method is applied to the data for births and maternal deaths in the birth registration area of the United States for 1918, the total rate and the rates for causes under the important rubrics are conspicuously high. The total rate is more than double that for England and Wales calculated on live births alone, and this is due to the great excess in the United States' rates for puerperal albuminuria and convulsions and septicemia, and accidents of pregnancy and labor.

In the birth registration area of the United States for 1918, the total rate in urban communities was considerably greater (10 per cent) than that in rural communities.

In the four states, Kentucky, Maryland, North Carolina and Virginia, and in the cities, Washington D. C. and Baltimore, Maryland, the total rates and the rates for the most important rubrics are much higher for negro than for white women, and the negro rates are markedly in excess of the whole in both city and country. The rates for both white and negro women are higher in urban than in rural communities. The excess in total rates in relation to both race and location, is due chiefly to higher rates for puerperal albuminuria and convulsions and septicemia.

As determined for the birth registration area of the United States for 1918, the age of mothers exerts a marked and progressive influence upon maternal mortality from causes connected with child bearing.

As compared with Birmingham, England, and with Stockholm, Sweden, the maternal risk-rate in child-bearing is much higher in New York, Philadelphia, Baltimore, Boston and Washington, D. C. and in the order named. The total rates in these American cities are lower than the urban and rural total rates for the birth registration area of the United States for 1918.

The proportion of stillbirths to total births varies considerably in different places and in different races. In the birth registration area of the United States, the proportion for urban and rural communities is approximately the same, and the proportion for the negro is double that for the white, and for the urban negro somewhat greater than for the rural negro.

Sex Factor in Disease. In a paper on the "Susceptibility of the Sexes to Disease," published in the Finska Läkaresällskapets Handlingar, Helsingfors, for January-February, 1921, R. Ehrström "has compiled statistics which show the preponderance of certain diseases in one or the other sex, and discusses the causes for the lesser resistance in one sex. Gout heads the list with 40 men to 1 woman affected; color blindness, 10 to 1; Thomsen's and Leber's diseases, 10 and 8 to 1; chloroma, 3 to 1; diabetes, bronchial asthma, paralysis agitans, and hereditary nystagmus, each 2 to 1. In contrast to this, vasomotor neuroses are found in 20 women to 1 man; exopthalmic goiter 15 to 1; osteomalacia, 10 to 1; arthritis deformans, 6 to 1; myxedema, 5 to 1; gallstones and scleroderma, 3 to 1; endemic goiter and chorea, each 2 to 1. These are pathologic conditions in which endogenous factors participate, and the predilection for a certain sex suggests that the sexual organs and sexual characters are involved in their mechanism. It demonstrates further, he adds, that the influence of the secondary sex characters is more profound and far-reaching than has been realized hitherto." It must be remembered however, that in at least some of these cases there is involved the principle of sex-linked inheritance, as in color-blindness.

Jour. Am. Med. Asso., April 30, 1921.

Social Facts Relative to Patients with Mental Diseases. By Furbush (Edith M.)—8°, Publ. by *The Nat. Comm. for Ment. Hyg.*, N. Y. 1921, 25 pp.

Report based upon statistics compiled in accordance with the uniform system adopted by the American Medico-Psychological Association and promulgated by the National Committee for Mental Hygiene. It presents data concerning nativity, citizenship, marital condition, environment, economic condition, age distribution and alcoholic habits of patients who entered hospitals for mental diseases for the first time during the fiscal year 1919. In the April number of *Mental Hygiene* these same admissions are studied from the point of view of their types of mental disease. (Mental Diseases in Twelve States, 1919.)

The report in full of interesting data which it is impossible to quote in this brief review.

A Comparative Inquiry on the Heredity and Social Conditions Among Certain Insane, Mentally Defective and Normal Persons. By Kelley (Agnes) and E. J. Lidbetter.—*Eug. Rev.*, July, 1921, XIII, No. 2, 394-406. (Repr. fr. II Ann. Report, Bd. Control, 1915).

A fairly extensive inquiry in above directions has shown the following results:

A certain disassociation was seen between the types of stock that give rise to Insanity and those that give rise to Mental Deficiency. Pedigrees of Asylum patients showed considerably more Insanity than Mental Deficiency among the relatives. Conversely, Mental Deficiency was very much more prevalent than Insanity in the family histories of the Special School children.

There was more Mental Deficiency among the Asylum cases than there was Insanity among the Mental Defectives.

The general level of intelligence and health among the brothers and sisters of Special School children was poor, and distinctly below that of the Normal children.

The intelligence of children of Asylum patients appeared to be more uneven, and though many were bright and intelligent, children who were erratic, unstable, dull or backward, were frequently reported.

A great variety was seen in the type of stock in the Asylum group. There were some pedigrees in which the individuals were living independent, useful lives, working at good trades, earning good wages, and intermarrying with respectable families; the patients themselves earning their own livings and supporting their families before the mental breakdown occurred. There were at the other end of the scale pedigrees of families of a degraded type, the whole family low wage earners, frequently of loose morals, living in poverty stricken homes, and intermarrying with equally poor stocks. Such families had weakly, uncared-for children, and were intermittently on the parish.

Good trades and high wages were even less common, and were in fact rare in the Mentally Defective group. Though there were some exceptions, the general level was poor, and there were many unskilled workers and casuals. There was a corresponding dead level of poverty in the home conditions of the majority of these cases, and the incapable (though often well-meaning) mother was very conspicuous in this group. In few of the Asylum cases, and among still fewer of the Mentally Defectives, could the home conditions be described as good, while one-third of the homes in each of these two groups were classed as "homes in which the food was quite inadequate, the clothing very poor and bare necessities were lacking."

The Practical Value of Scientific Study of Juvenile Delinquents. By Healy (William)—U. S. Dept. of Labor, Children's Bureau, *Bur. Publ.* No. 96, Wash. 1922, 8 vo., 31 pp.

A series of recommendations based on the sound assumption that:

"The study of the physical and mental qualities of a delinquent child and of his history and surroundings is an approach to the individual and his needs, rather than to an offense and its legal penalty. Therefore it is in so far an essential application of the philosophy on which the juvenile court rests."

The scientific study of juvenile delinquents must include, however, also the social conditions surrounding the case: "This greater conception points emphatically to the errors which must follow examinations

consisting merely of a series of physical and mental tests of the individual, however well devised, if unrelated to the social elements which may have conditioned the physical and mental state."

The Health of Missionary Families in China—A Statistical Study. By Lennox (Wm. G.)—Publ. by the *Univ. of Denver*, 1921, 121 pp. bibl., charts.

A study of facts concerning the health and family conditions of 60 per cent of the missionary families in China. Facts are tabulated concerning 1,300 marriages and 4,381 persons (1,577 adults and 3,254 children); 451 deaths of children, 59 stillbirths and 416 miscarriages and nearly 7,500 cases of sickness are analyzed. The principal facts which come to light are as follows:

Each marriage has resulted in an average of 2.5 children, which is at least 20 per cent more than that for the average college graduate or college teacher in the United States. Only 13 per cent of the marriages are childless, against 31 per cent among American college women.

American societies average 2.33 children per marriage, English and Canadian 2.63; European 2.88.

Three-fourths of the families have no children dead.

Mortality among these children is considerably less than half what it is among Chinese children but greater than among children of missionaries in Japan. The excess for China occurs in the group of children aged 1 to 5 years.

Infant mortality is low.

Death rates of children from the second to the fifth years are three times as high as in country districts in England having about the same infant death rate.

Mortality among these families in general decreases from north to south. It is more than twice as high in North China as in South China.

Mortality varies markedly in the various societies, the highest having three times the rate of the lowest. It is equally low in the American and English societies. The high rates found in other European societies are due to dysentery, diarrhoea and smallpox, each of which is two to four times as deadly as in American or English societies.

Mortality is lowest when a parent is born in China, highest when parents are born in Europe. Of the latter class 15 per cent of the deaths are due to smallpox.

Mortality has decreased for successive children through the fifth child, after which it has increased. Smallpox is six times as deadly among children born sixth or later as in earlier ones, while dysentery is less deadly.

Large families have a considerably higher mortality rate than small families.

Mortality rates are slightly lower for children born outside of China than for those born within. They are also lower in the groups of societies in which parents have spent the largest percentage of time off the field.

Dysentery has caused 19 per cent of all deaths, diarrhoea 12 per cent, respiratory infections 13 per cent, diphtheria 6 per cent, conditions associated with birth 10 per cent, smallpox nearly 5 per cent; 88 per cent of deaths have occurred before the age of seven.

Sickness rates, in contrast with mortality rates, are highest in Central and South China, due to increase of malaria and intestinal parasites. In South China also, fewer children have robust health. Dysentery in relation to years of residence is less prevalent in the coast and Yangtse Valley provinces. The absolute number of cases is greater in these sections because the number of missionaries is greater.

The largest number of dysentery infections occur during the second and third years, of diarrhoea during the first and second.

Miscarriages number 13.4 per cent of live births, the rate being highest in South China. The number of miscarriages per family is also highest in the south. Twenty-four per cent of the wives have had one miscarriage or more, a comparatively high rate: 87 per cent of miscarriages occurred in China, against 82 per cent of married years spent there. Travel and overwork caused a larger proportion of miscarriages at home than it did in China. Overwork, disability, nervousness, etc., are thought to be responsible for one-half of the miscarriages.

Stillbirths were 1.84 per cent of living births, a low rate, probably largely due to the absence of syphilis among missionaries.

Missionaries have been married an average of 11.6 years. The average adult life on the field is 20 per cent less in South China than in North China.

Most numerous diseases among adults in China in order of frequency are: malaria, dysentery, typhoid, nervous breakdown, influenza, diarrhoea, sprue, appendicitis, operations, smallpox, typhus fever, tuberculosis.

Cases of malaria and dysentery are much more numerous among husbands than among wives. In the case of sprue the reverse is true.

Forty-six per cent of the infections are contracted within the first three years after arrival in China.

More than half (53 per cent) of adult missionaries have had serious illness in China. Fewer have been sick in North China than in Central and South China.

Only twenty per cent of wives and thirty per cent of husbands say they have been in robust health. For wives the proportion is constant for the sections of China. For husbands, 33 per cent in the north have had robust health, against 17 per cent in the south. This is perhaps due to the especially high incidence of malaria among husbands in the south.

The proportion having robust health in various societies varies widely, but in general, the societies with high mortality rate among children have a low percentage of robust health among parents. In general, though mortality among children is much higher in the north, the morbidity rate among adults and children is less, miscarriages fewer, the general health better, and the residence in China longer for those who

live in North China. This is because the diseases of North China (dysentery, pneumonia, diphtheria, scarlet fever, smallpox) cause death. Those of South China (malaria, intestinal parasites) and the climate, cause invalidism.

Among adults and children here reported (about 41 per cent of the total missionary body) dysentery has caused 808 cases of sickness and 84 deaths. Typhoid contracted by adults in China outnumber cases contracted by them at home 12 to 1.

One hundred and eleven cases of smallpox, with 28 deaths, are recorded among children and adults, a rate 95 times that for the general population of the United States. Only one death occurred in a person who had been vaccinated.

In certain sections of China, or among certain groups, children of missionaries have as good a chance for life and health as children at home. Taking the missionary body as a whole, however, there has been an excessive loss of life among both children and adults. Much of this loss may in future be prevented.

Mongolian Idiocy and Hypopituitarism.—Dr. Walter Timme has found an abnormality in form of the sella turcica in twenty-three out of twenty-four cases of Mongolian idiocy. There is much in the habitus of these defects that suggests dispituitarism—stunted growth and imperfect development of the genitalia. By injecting anterior lobe extract, some improvement has followed.

Arch. Neurol. and Psychiatry, May 1921.

da Costa Ferreira (A.A.)—Contribuiçoes para o estudo de osteologia des Microcéfalos. *Arq. Anat. & Anthrop.*, Lisboa, 1920, VI, 37-63, 6 pl.

A detailed description, with measurements, of three interesting Portuguese microcephalic skulls. Recognises two types of microcephalic crania, the disharmonic, with pithecoid appearances, and the harmonious, infantile.

Hereditary Exostoses.—A short article descriptive of a family showing "Hereditary multiple cartilaginous exostoses" is published in the Journal of the American Medical Association for February 26, by H. H. Maynard, M.D., and Clifton R. Scott, M.D. The article is illustrated with Roentgenograms and a family pedigree chart showing four affected generations. "The disease shows a marked hereditary factor and is transmitted by male or female." The family history does not support theories of infection. There are some fourteen citations from the literature.

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CRANIAL CAPACITY AND LINEAR DIMENSIONS, IN WHITE AND NEGRO

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CONTENTS

I. The Direct Determination of Cranial Capacity.

HISTORICAL INTRODUCTION

It is not my desire to deal exhaustively with the vast amount of work already done upon the measurement of cranial capacity, the technique of the various types of determination, or the difficulties encountered. For those who wish a short introduction to the subject the accounts by Martin (32) and Hrdlička (23) form a good synopsis. The former is more comprehensive and deals also with the mathematical aspects of the study. The latter warns the reader of some of the errors to be encountered and details a method which is likely to give fair and comparable results. Of this I have no actual experience because, as will appear later, our problems have not so far been such as to enable us to use Hrdlička's apparatus profitably.

Nevertheless it is necessary to make a brief survey of the several methods proposed for the determination of cranial capacity in order to examine their reliability. While many authors give special details for their choice of a particular method or of their peculiar difficulties, the papers most helpful historically upon the direct measurement of capacity are those of Broca (13), Schmidt (47), Welcker (64), and Bartels (1). It will be noticed at once that all these date from before the beginning of the present century. I have made this distinction purposely, for the introduction by Pearson, during the nineties, of a scientific survey of cranial capacity based upon appropriate mathematical principles, and since then developed by Pearson and his pupils, has given to capacity determination a new stimulus borne of the confidence which results from methods of precision in the analysis of assembled data. Hence papers

which have appeared more recently, which ignore or minimise the great additions to our knowledge and technique resulting from labors of the workers in the Biometric Laboratory of University College, are correspondingly less useful and may for the most part be passed over.

To those who would study seriously the question of capacity determination there can be no finer introduction than the masterly monograph of Broca(13). In his most racy and delightful manner Broca gives the history of capacity determinations; the difficulties encountered, not by former writers, but by himself in attempting to carry out the methods put forward by others; and his final recommendations for a method which shall of all be most nearly exact.

Soemmering it was in 1785 who first published the account of an effort to estimate the cranial capacity. His method was the simple one of filling the skull with water. "Le procédé le plus ancien, et aussi le plus défectueux," Broca comments (13 p. 69). Saumarez, in 1798, using the water method, confirmed Soemmering's statement that the cranium of a White man is more capacious than that of a Negro. Virey, in 1817, went a step further, also using the water method. He found that the male cranium whether of the White man or the Negro is more capacious than that of the female of the same stock, and that the female White cranium is somewhat larger than that of the Negro male. Virey was assisted by Palissot in his later estimations. The water method was then abandoned until revived by Volkoff in 1847, and Huschke in 1854 (24). Huschke's method was the usual one of estimating the volume from weight of contained water after stopping up all holes.

Sir William Hamilton introduced the method of filling the cranium with sand in 1831. This method quickly became adopted especially in England, but it is interesting to observe that Hamilton and all who preceded him did not measure the volume of the cranium but the weight of the material introduced. From the specific weight of sand Hamilton attempted to calculate the brain weight. Barnard Davis, however, by the same method shortly afterwards determined, not brain weight, but cranial capacity in cubic inches. In 1837 came the next step, namely the substitution of millet for sand by Tiedemann who induced many of the Anatomists of his time to send him results obtained by his method to increase the size of his tables. Most fascinating in Broca's monograph is the recital of Tiedemann's romantic ideas and his absolute inability to carry out the simplest arithmetical technique. In 1849 Morton, in a publication which I have been unable to obtain (36), published an account of a method involving shot, not as his first but rather as his

last choice for he and Phillips had already experimented with white pepper (Broca calls it mustard) seed and mercury (35). These observers like Barnard Davis measured the capacity directly.

In 1861 Broca himself began to experiment with Morton's shot method but found that he could not get a less difference than 40 cc. between successive determinations even with assistance. This was a difference of about 3% upon the total capacity. Now Morton had claimed a divergence of no more than 1% but he did not measure to less than one ounce (16 cc.). Hence we may conclude that, upon the most optimistic basis, Morton's measurements were correct to within 2% of the real figure. Broca however concluded that his assistants might be to blame. He therefore dismissed these two young men, one of whom was Bertillon and the other Chavassier, and performed all the manipulations himself. This time he found a difference of 61 cc. or 5 % between his determinations. Discouraged for the time Broca turned to a method not hitherto used, namely estimation by means of a vulcanized rubber bag inserted into the cranium and then filled with water. On distension this did not occupy all parts of the cranium cavity and burst on the posterior clinoid processes upon the third attempt. A second and stronger bag burst in the first determination. Previous to this there had been developed by Stahl (10) and Jacquart (13) at the Museum d'Histoire naturelle a method involving making a gelatine cast of the interior of the cranium, reproducing this in plaster and determining the volume. About the same time Wagner made the suggestion that the relative capacity of crania might be obtained by weighing the plaster cast. This would eliminate the increase in dimensions undergone by plaster when wet, so well shown by Broca (11). But weighing proved impracticable on account of the varying specific weight of different samples of plaster. Welcker (62) in 1862 pointed out that since the volume of the cast and not the weight is wanted, the cast might be varnished and the volume then determined by displacement in water. All these manoeuvres are very tedious and, in practice, impossible to carry out as a general rule. Lucae adopted the method for a time but soon gave it up. Broca never attempted it. Having come to the conclusion, as the result of direct study, that gauging the capacity by the introduction of solid granular material is the only practicable method to be followed, Broca set himself to determine the most satisfactory substance and the technique which would give least variable results. He decided upon No. 8 shot, 2.2 mm. in diameter, and gives elaborate directions for the efficient employment of the method. One would wonder why Broca spent so long a time and so much energy

upon this one problem. It is true that the problem is important but its importance was undoubtedly greatly emphasized by the long and vigorous discussion in the Paris Anthropological Society during the year 1861 upon the volume of the brain in different grades of intelligence and among different races (20, 9). It is further interesting to observe that this conference occurred immediately after the Society had taken notice of a movement in the United States to prevent race degeneration. The Legislature of Ohio had taken the initiative by passing a law forbidding consanguineous marriages (18). It is most significant that this particular discussion, the recrudescence of a controversy regarding relative volume of the brain in White men and Negroes, which Tiedemann had attempted to settle, should, at one stage, revolve around the effect of slavery in North America upon the Negro's brain (9).

There is no new information in the article by Schmidt, (47, 1882) except the corrections for Broca's technique. Schmidt fell under Broca's magnetic influence and reviewed very carefully all Broca's work. He gives in detail Broca's directions and shows how accurate Broca's method really is, with the reservation that it gives a reading almost always centering about 80 cc. above that which would be obtained with water. We must accept Broca's results as being practically constantly about 70–80 cc. too great.

In 1883 Ranke published his method of making a crâne étalon of bronze (43). A personal communication from Topinard to Ranke confirmed Schmidt's observation that Broca's efforts to stop up all holes in his crâne étalon were not perfect and in consequence the determination with mercury was too large. This naturally vitiated all Broca's determinations by other means.

Broca's painstaking investigations stimulated much further work upon cranial capacity and many Anatomists began to make and exchange crânes étalons and to check each other's results (51, 55). Ranke's Bronzeschädel was of great service for, as Topinard pointed out, it is not easy to make a good crâne étalon from an actual skull; he would waste six or seven in the effort to make two (52). This was obviously a discouraging circumstance when a real attempt was being made to circulate these crânes étalons and compare results. The error into which he had fallen by using an actual skull as a standard was quite well recognized by Broca himself, as Topinard testifies (52), nevertheless when this error is discounted Broca's results are wonderfully uniform as Schmidt was at pains to affirm (47). After Broca's death Topinard took upon himself, as a duty to his master, the most assiduous review of Broca's method, in

order to rectify the original error. In his summary before the Anthropological Society of Paris Topinard advised that 6% be deducted from Broca's published figures in order to ascertain the true value for each skull (3).

In 1886 Welcker's large monograph appeared (64). He dealt at great length with various aspects of the subject but his method of attack was not nearly so critical as Broca's. Returning to a very simple and uncontrolled method using peas, he seems to have been easily satisfied that all the advantages lie with grain rather than with shot. The looseness of Welcker's technique, of his controls and indeed of his writing form a strange contrast to Broca's well-knit and forceful presentation. The mathematical side of Welcker's work displays the same weakness and will receive attention later.

Ten years later Bartels (1) modified Welcker's method in several respects. He found that the apparent simplicity of the method existed solely in Welcker's statement, and proposed to return to a light and even packing in skull and cylinder. He further weighed the peas instead of measuring their volume. He used Ranke's Bronzeschädel as a standard and comments favorably upon the constancy of the result obtained. His experiment however only involved three skulls which he recognizes as possibly a small number. Of course Bartels' method is simply a return to the technique of Tiedemann.

Two years earlier, in 1894, Mies made an attempt to return to the water method (34). The method is long, very complicated and plainly no advance upon the accuracy of other simpler methods. Besides, the indiscriminate use of putty and water cannot be indulged in without damage to the skull. Mies had only eleven skulls at most upon which he could have tried the method in 1894 but it does not appear that he did more than mention having previously suggested it.

During these years Matthews in Washington had been varnishing skulls and determining their capacity with water, a method quite indefensible on account of its harmful effect upon the skull, but Matthews claimed that he used the rubber bag as far back as 1884 although he did not publish an account of this until 1898 (33) after Krause had brought forward Poll's modification in 1896 (26, 42). No essential improvement has been or could be made upon Broca's discarded technique with the bag although others have occasionally used it (Pacha, Russell 46).

At first Waldeyen gave Poll's method only mild support but by the following year he had become so convinced of its value that he regarded

the search for a reliable method of estimating cranial capacity as finally closed (69). Throughout he spells Poll's name as Boll.

In 1900 von Török revived Hölder's method of determination with glass perles (54) without however giving the earlier worker any credit for the method. The idea of using glass perles was suggested to Broca by Mme. Clémence Royer but he had no opportunity of employing it (13). After reviewing a very few previous methods and their disadvantages Török advocates glass perles of 5–6mm. in diameter, as being four and a half times lighter than shot and only 1.74 times heavier than peas. Using as a standard one of Ranke's Bronzeschädel Török found a less divergence between successive readings with glass perles than with peas of the same size, in the proportion of 6.1 cc. for the perles to 26.1 cc. for the peas, the volume being read upon the graduated cylinder. Upon this showing Bochenek recommends the method as the most exact and practical. Nevertheless there are so many problems connected with the technique of the observations left entirely untouched by Török in his discussion that one cannot accept it as a critical study. I am therefore by no means disposed to accept such accuracy for the method as that claimed by Török.

During the present century efforts to introduce new methods or new modifications of old methods have become less frequent. As a rule workers have accepted one of the established procedures although there is ample evidence that modifications have been made.

About the year 1900 a special method for measuring the cranial capacity in dry skulls was devised by Hrdlička (22, 23). Finding it difficult to secure accurate and steady results by the already recounted direct methods, Hrdlička conceived the idea of regulating a part of the procedure mechanically in such a way that practically all personal error so far as that part was concerned was excluded. The method, which has since been used extensively in American anthropological laboratories, and which is eminently adapted to measuring fragile skulls as well as other specimens, consists in using dry mustard seed; in the filling of the skull with this by the Flower method; and in emptying the contents into a special funnel and vessel of standardized dimensions which regulate the flow of the seed into a graduated glass tube. The procedure is further regulated before the commencement of any series of measurements by tests on standard skulls of different and known capacity. It is a more rapid and easier method than any other used previously or since upon the dried skull, and with careful practice gives results which show a variation of generally less, and never more, than 15 cc.

Thousands of measurements of cranial capacities of American and

other racial material taken by this method are soon to be published in a "Catalogue of the Measurements of Crania in the U. S. National Museum Collections."

In 1902, Weinberg used sago as a substitute for other vegetable grains (61) and checked off his method against shot in a crâne étalon. Obtaining harmonious results he suggests the substitution of sago for shot because of its lower specific weight.

The following year Landau (27) introduced aluminium shot in a modification of Welcker's method, using an apparatus similar to that designed by Hrdlička (22).

In 1903 also Pfister carried out a careful piece of work upon the cranial capacity of the child's natural (i.e. fresh) craniun, simply pouring water into the cranial cavity after the usual horizontal autopsy incision, removing the brain and closing off the foramen magnum (41). This had been suggested by Zanke six years before (66).

Zanke's observations were carried out on the fresh skull in the cadaver and also upon the dried skull. The former series was obtained by the simple expedient of filling the two parts of the cranium after the ordinary autopsy incision had been made and the brain removed, taking care to plug the foramen magnum and to avoid error by water filling the lateral sinus. In the macerated skull he endeavored to reproduce the same conditions as in the cadaver by using a pig's bladder, thoroughly softened to replace the dura, wrapping the bladder over the cut skull margin. The method is not recommended for the uncut macerated skull. On the fresh skull Zanke claimed an error of not more than 10 cc. when the measurement is repeated two or three times in order to assure confidence in the result.

In 1905 Reichert (44) applied this technique to the adult cranium. In the same year Vitali (58) brought forward a method calling for immersion of the skull in water, a method very similar in type to that of Mies (34) and with the same obvious disadvantages. This submerging of the entire skull in water had been carried out by Schmidt in 1880 in his search for a modulus (48). After rendering the outside of the skull watertight Schmidt submerged the skull in a vessel so arranged that the skull was immersed exactly as far as the Frankfort plane.

In 1911 Froriep (17) having the opportunity to cut the skulls upon which he was working, returned to the cast method of Stahl and Jacquart. He compared this with the shot procedure and advocates the cast as the more exact of the two. He recognizes that it is not always possible to carry out this method.

In 1914 Szombathy (49) brought forward again the use of peas but he believes in packing which he claims to have advocated first in 1880.

ACCURACY CLAIMED FOR THE SEVERAL DIRECT METHODS OF MEASURING CRANIAL CAPACITY.

For our guidance in determining the amount of confidence we may place in the direct measurement of cranial capacity it will be advantageous to review the errors as recorded by previous workers. According to the results of Broca's critical experiments (13) the intra-cranial cast gives a determination 60-70 cc. wide of the mark; the rubber bag method is as bad and, at best, the estimate will be 50 cc. too low. The mercury method is very exact and gives readings differing by only some 4 cc. For this reason Broca used the mercury method for standardizing his famous crâne étalon. Water, though an impossible method in practice will with care give a determination constant within 12 cc.; the method is more difficult than that with mercury and not so exact.

Results from methods involving the use of vegetable seeds depend upon many circumstances affecting the humidity, packing or density of the grain. The best that can be hoped for is a divergence of some 12-18 cc. and it must be remembered that the method is only approximate; it cannot be depended upon to give this small error. Of shot the size tried were No. 4 (3 mm. diam.), No. 8 (2.2 mm. diam.) and No. 12 (0.9 mm. diam.). With No. 12 the maximum and minimum results differed by 17 cc.; with No. 8, 33 cc.; with No. 4, 40 cc. No. 12 was just as unsatisfactory to work with as sand and No. 8 was finally chosen. We therefore note that by Broca's showing upon his own technique in Morton's method we may expect reasonably to get a result within 35 cc. of the actual value, but in his later work Broca claims a possible error of not more than 5 cc. (13. p 152; 10. p 106; 14. p 63) This constancy of result is substantiated by his work on the influence of humidity (14).

Conclusive evidence has previously been cited showing that Broca's mercury method gave a result higher than the actual value since some of the mercury percolated into the crevices and foramina of the crâne étalon. In view of this error it is remarkable, and in the present discussion deeply significant that the mercury method, in Broca's own hands gave readings varying from one another by less than four cubic centimeters.

Passing then to Welcker's account (64) we find that he claimed a divergence of readings of only 15 cc. when he himself made the observations. This is practically the same error as Broca found for the same method.

Bartels (1) however could not accept this small divergence for the average worker who should use Welcker's method; he estimated a probable difference of 40 cc.

Poll (42), using a rubber bag upon a Ranke's Bronzeschädel and twelve actual skulls, gives a divergence in readings of some 10 cc. and does not find any significant difference between the results of observations upon the bronze skull and upon actual skulls. Russell (46) who gave the method at least an equally painstaking trial found a variation of five to eight cubic centimeters in readings of capacity in actual skulls. The variation was found by Russell to be greater in a Bronzeschädel because the air was retained between the wall of the bag and that of the air-tight "skull." Incidently Russell estimates variation in result by the direct water method as eight cubic centimeters; and by the shot method as 16 cc., the average being 40.8 cc. in excess of the real value. Bochenek repeated the experiments with the bag (8) and got results varying by some 29 cc., the average being about 27 cc. too small.

Törok (54) claimed for the glass perle method a maximum accuracy of within 6–7 cc., but I have given my reason for rejecting this estimate. Hrdlička's method gives generally results within 10 cc. variation. Weinberg, it may be inferred, anticipated an error for the sago determinations(61) of no more than Broca's shot method. Froriep(17) does not give exact estimates of the error of his cast technique but it is plain that he did not take unusual pains with his shot method and he admits that other workers might have obtained higher values by the latter method, that is to say, values closer to those which he obtained by the cast. Reichardt (44) gives one greater confidence than most authors for he states that the water method in the fresh skull is not without its error. "Es soll also eine Methode für praktische Zwecke sein; es wird hierzu völlig genügen, wenn die Fehlerquellen dieser Methode unter 50 cbcm liegen." Pfister's method also falls in line with this.

THE PERSONAL ERROR IN APPLICATION OF DIRECT METHODS TO THE DETERMINATION OF CAPACITY

Having given consideration to the accuracy claimed by the various introducers of methods and modifications of methods we must turn for a moment to the application of these methods by others who may be as yet unconvinced of the justice of the claims made. Full criticism of the water method, in which we have had considerable experience, will appear in the memoir but it will then be apparent that, constant as the successive determinations of a single observer may be upon the capacity

of a chosen skull, this constancy by no means implies a like value for the capacity when estimated by another observer even when his results are likewise constant. This stricture is applicable to all methods and can only be surmounted by careful collaboration in technique and not even always then as I shall shortly show. Hence we must be very careful not to overestimate the exactitude in comparison of series of measurements by different observers even with the same method.

In the preceding section I have pointed out the comments upon accuracy by various investigators who have employed the methods introduced by others and I have compared the claims of accuracy by both workers. It must of course be understood the word accuracy in this connection simply means constancy of result. It is worth while to examine the several methods in relation to the special problems of our own work.

The method which calls for filling the skull directly with water is obviously the best but is rarely applicable since nearly all skulls of which the capacity is to be estimated are macerated and dried. Actually to render the skull impervious to water and then take the capacity by the water method is a long and tedious procedure and usually not to be considered. The rubber bag scheme has not come into general use because of wastage of bags and uncertainty as to whether the bag is actually in contact with every part of the cranial wall. Bochanek (3) estimates that the life of one bag is no more than fifteen measurements.

The danger of Broca's shot method to a fragile skull is obvious; hence Welcker(64) substituted peas. Bartels attempted to avoid the error associated with the varied packing of the peas in the measuring vessel by weighing them instead and then converting the weight into a measure of volume (1). Other authors have used sand, the weight of which is as objectionable as that of shot. Others again have used various seeds smaller than peas, glass or aluminium balls.

None of these methods have proved quite satisfactory in spite of elaborate precautions regarding packing or shaking of the seed in the cranium or the measuring vessel. Great care has been taken over the precise type of container for the seed, the method of pouring the seed into the measuring vessel, the height of fall of the seed, and the control of packing. Nevertheless results with all these precautions remain unconvincing. Topinard indeed stated that he could vary the cranial capacity 150 cc. more or less at will and that this difference could easily be obtained by different workers especially if they were not very careful of technique (52). One of our own special difficulties has been to find a method

of measurement which would be equally applicable to a cranium of Man averaging say 1400 cc. and to a cranium of Hylobates averaging perhaps 98 cc. In spite of Poll's warm recommendation of the use of the rubber bag method for the skulls of children and mammals (42), the rubber bag is just as insecure and unreliable for these skulls as for the larger skulls of adults. It will not do to pass off the matter, as some authors have done, by saying that correspondingly smaller measuring and collecting vessels should be used. This is the statement of one who, obviously, has never attempted to carry his suggestion into practice. If for a trial one measure with white mustard seed, the capacity of a human cranium, using in one instance one 2000 cc. cylinder, and in the other two 1000 cc. cylinders one will not obtain the same value, whether one does or does not pack the seed. Seed packs by its own weight and the height of fall has something to do with the automatic packing of the seed. From this again it will be seen that the term "correspondingly smaller vessels" must be accepted with caution. Bartels' method of weighing the seed has obvious advantages in this problem. The exact seed to be employed, according to Broca (13. pp 76, 105, 106) is not important. Some use white pepper seed because the grains are hard, heavy and fairly uniform in size; others prefer millet which is said to pack better owing to its spindle shape.

W. R. Macdonell gives a detailed and excellent account of the procedure in determining cranial capacity by the use of hard dry mustard seed (39). After some experience the realization of a considerable possible error through variations in packing of the seed in the measuring cylinder led Macdonell to adopt Bartels' method of weighing the seed instead of measuring it. Instructive evidence is cited of the error entailed by the latter method. It is also interesting to note that the possible error resulting from absorbent quality of the seed, such as was feared by Bochenek (8), is found by Macdonell to be negligible. Indeed it is obvious from Macdonell's work that Bartel's modification of Welcker's method is a distinct improvement, Bochenek's assertion to the contrary notwithstanding, at least if mustard seed be used. However it is not our present intention to deal in detail with these difficulties. To them we shall return in the discussion of the cranial capacity of the Anthropoid which we propose to take up in a later communication. The description serves to show how dubious must be the value of any direct method even in careful hands. We may as well acknowledge that the method is in essence a crude one and too great reliance must not be placed in it.

In making the assertion that accepted methods for the direct measurement of cranial capacity are in essence crude, one does not forget that

Virchow pointed out long ago that absolute exactitude in estimation of cranial capacity is not of the slightest service to Anatomist, Physiologist, Pathologist, or Psychiatrist (57). Virchow was speaking of a supposed error of some 6 cc. in the cranial capacity of a human skull. Therefore it behoves us to note what the probable error may be in employing the methods already indicated. Over and above the purely instrumental errors, at some of which we have glanced, there are personal errors which, in my opinion, cannot easily be overcome. There are bound to be slight differences between the results obtained in two different laboratories even when the same type of instrument is used in the same manner; these differences must be accepted. But differences are also found when two observers are using the same instruments in the same laboratory and it is suggested that the two observers should be able to obtain comparable results by watching and working with one another. For the purpose of the moment it will be enough to state that Miss Russell and I have carried out this principle in this hope during three months' work and at the end of the time we still have to weight our respective series as we had to do at the beginning. I do not believe that practice avails much in the elimination of this source of error but I shall discuss it more fully upon another occasion.

The type and extent of the errors resulting from the use of different methods and the work of different observers have been considered already by Miss Fawcett (16). Three skulls were measured independently and at various times by four investigators, the results showing a maximum difference of 37, 43 and 66 cc. respectively. The difference between the mean capacity of the Naqada skulls as determined by Miss Fawcett and by Thompson is 48. cc. for the males and 36 cc. for the females. Miss Fawcett estimated that eliminating all other sources of error the personal factor would itself account for a difference of 20 to 30 cc. in the determination of capacity in individual skulls, a difference say of 2.0%. On our experience I should consider this quite an optimistic estimate. Macdonell gives evidence that on very short series different workers using the same method may hope to attain average estimates differing by no more than 10. cc. and if different methods be used, by not more than 20 cc. (30). I think we may consider this the best that can be attained. The work must necessarily be done in a single laboratory. I do not hope for so good results if the same skulls were measured in different laboratories.

Now upon a difference in mean cranial capacity no greater than 30 to 40 cc. theories of racial values have been built. Usually also the series

have been very short so that the racial distinctions must seem at least dubious. In this laboratory we are dealing with a White material of heterogeneous character drawn from various parts of Europe in addition to the much more heterogeneous White material indigenous to the United States. We are dealing also with a fascinating Negro material which however heterogeneous when first imported has had, during the past three hundred years, little or no opportunity to increase its heterogeneous nature. Indeed, setting aside the admixture with White blood, of which I am convinced far too much is made, the American Negro may possibly be now one of the most uniform of races. I shall not labor this suggestion at the moment: it forms one of the most instructive and fruitful problems which the Hamann Museum provides for study and its various phases will be set forth in later communications. Nevertheless it will be seen that one of the main objects in the study of the skeleton in this laboratory is the estimation of true racial features, or as perhaps one might more accurately express it, the evaluation of characters of the different human stocks to be found in North America. In the case of cranial capacity we must adopt a method the personal and instrumental errors of which are within strictly reasonable limits, limits which can be estimated fairly accurately. The method must not be cumbersome, must be applicable to a rapidly growing material and must not require the expenditure of an undue amount of time. These limitations are fairly stringent but there are others quite as grave once one begins to work with the material. It is a rule of the laboratory to cut all skulls in the median sagittal plane in order to preserve the brain. As will be shown this procedure does not appreciably increase the difficulty of determining cranial capacity on the fresh skull. But a large minority of the material has already suffered post-mortem examination at the hospital, and in such material the direct estimation of cranial capacity with an accuracy even within 40 cc. is almost hopeless on account of the barbarous although scientific manner in which Pathologists in America are compelled by public opinion to remove the calvarium. Further there is a second large minority of material upon which I had no opportunity of directly determining the cranial capacity by the standard water method about to be described, since I was engaged not long ago in quite other, very necessary and absorbing although temporary duties in the War. When these two disturbing factors are appreciated it will be understood why, upon so large a material, the number of skulls having records of cranial capacity in the recent state, is relatively small. It is also obvious that we cannot go back and measure the old material by

another method when so much new stock is arriving. Hence we determined to turn to the mathematical computation of cranial capacity. We have enough material (as such series go), the capacities of which have been fairly determined directly to enable us to check up the mathematical method, and we desired first of all to do this. Beyond this preliminary investigation our problems are; first, to determine as accurately as possible the cranial capacity of individuals both White and Negro; and secondly, to obtain data upon the cranial capacity of the American Negro as a race. We did not expect to better the results of direct determination but decided that we should be satisfied if we could obtain results comparable in their accuracy.

DETERMINATION OF CRANIAL CAPACITY BY THE WATER METHOD UPON FRESH SKULLS

We have already discussed the use of the water method of determining cranial capacity as applied to the fresh skull by Zanke, Pfister and Reichardt. We have considered the fact that the supporters of this method claim for it that it is, by its nature, a practical method and gives a result accurate to about 50 cc. that is to say within 3%. We have checked this off against the claims for greater accuracy of the supporters of other methods, and we have been impressed with the convervatism of those who uphold the water method. Further we find on re-investigation that this method is quite all that is claimed for it in ease and in accuracy whereas the claims put forward for other methods have not stood up so well under critical examination. Nevertheless there is really only one type of material, which is amenable to this method, namely fresh non-macerated skulls of which the capacity measurement has not been rendered difficult or even impossible by treatment in the autopsy room. It is the method which we have consistently used in this laboratory over a period of eight years. By it we have obtained our standard determinations for the computation of capacity by statistical means It is therefore necessary to describe our technique, the various tests of accuracy and the process by which we propose to render our results comparable with those of other workers by other methods.

SKULL TECHNIQUE

It may be well to state that the procedure about to be described interferes with the full amount of information which the student would otherwise be able to obtain from the head, provided his interest did not flag towards the end of the arduous dissection of this part. We find by

experience that tedious work upon the head involving orbit, ear and cranial nerves is shortened and a student's knowledge greatly strengthened by completion of these dissections upon the term foetus rather than upon the adult skull. This dissection of the foetus rounds off the practical work in Anatomy and insures that the student leaves the department with some realization of the differences to be found between the anatomy of the adult and that of the child, a most important part of his anatomical training in preparation for clinical work. The scheme also insures the salvage from destruction of valuable skeletal material so ruthlessly wasted in most laboratories in consequence of traditional anatomical methods. After dissection of the neck and face, the head without the mandible, is turned over by the student to prosector Leonhart who strips off the soft tissues from the cranium and the external auditory canals. The skulls thus prepared, each one identified properly by means of a brass tag bearing the number of the cadaver and affixed with copper wire to each zygoma, are then brought in batches to the anthropological room where the author measures their length, breadth and auricular height by the technique shortly to be described. After this is done they are returned to the Prosector who carefully cuts each on the band-saw in a sagittal plane immediately to one side of the sagittal suture. This is done by turning the skull round on the saw so that while the palate and cranial walls are completely severed the brain remains uninjured. The intact brain is removed, labelled and laid away in storage against later investigation. A brain obtained from the autopsy room of the associated hospitals is substituted so that the student will not lack opportunity of dissecting the organ. The number of brains complete with all data and with their respective skulls can be appreciated from the number of skeletons upon which this paper is based.

The brain having been removed and the determination of cranial capacity made as later described, the fresh skulls are sent to the photographic room where the lateral nasal wall of the one-half and the septal wall of the other are photographed stereoscopically so that the exact condition of the cartilages, turbinates and lateral nasal wall may be known in later work upon the nasal cavities. Following this the half skulls are drilled, pegged and re-united in the Prosector's room and returned to the anthropological room where the measurements previously made are repeated to check up the former data and allow for the saw cut. After these observations have been completed the skulls are taken back to the dissecting room and the students for examination of the membranes. In those cases where a second estimate of capacity

is to be made the skulls must be brought back to the Prosector's room within an hour or two.

Between all these manipulations the skulls are kept submerged under water. The total procedure seems somewhat more lengthy than it really is. The work being thoroughly organized and all parts of it completely standardized, each batch of approximately twelve skulls is back in the dissecting room within twenty-four hours after it was first delivered to the Prosector. Thus students lose no time in their work.

Determination of the cranial capacity is carried out directly the Prosector has sawn the head and removed the brain. Indeed capacity measurement upon the batch begins as soon as two or three skulls are prepared. All the instruments required are two pans with handles and a good lip or spout, and two 1000 cc. graduated cylinders. Each half of the skull is measured in turn. The half skull is shaken thoroughly to get rid of any water which may remain in the frontal and sphenoidal sinuses and other places from which it might flow later and vitiate the determination. The loose ends of membranes like the falx cerebri are returned to the cranium, a thumb used to close the portion of foramen magnum, and the half skull filled under the faucet brimming full with cold water. Care is taken that none get into the sinuses. The water is then emptied into one of the pans. The other half of the skull is treated likewise. The water from each pan is then poured into a graduated cylinder and one filled from the other to the 1000-cc. mark. The total cranial capacity is then read from the second. The total capacity is estimated twice, repeating all manipulations and the average of the two determinations is entered on the record as single estimate provided the two determinations are within 15 cc. of each other. Should the divergence of the readings be greater than this the capacity is estimated once more. This reading will be almost certainly within 15 cc. of one of the former observations, in which case the aberrant one is discarded In the case of two initial determinations which differ by 16 cc. to about 30 cc. when the repeat estimate falls almost equally between the two, a fourth determination is made and the average taken of the two observations between which there is the closest agreement.

The capacity determination thus arrived at represents the capacity in the fresh skull with all the membranes in place, including the falx cerebri. It may, but usually does not, include a very few cubic centimeters of water from the venous sinuses. As it stands the determination is comparable with the observations of Pfister made on the fresh skull in much the same manner. For reasons which appear later it is also

directly comparable with determination made upon the dried skull by any dependable method.

The possible errors of the method are not many but they should receive careful consideration. We shall take them in the order in which they are liable to occur. The saw cut may be slightly concave towards one side or may not lie as close to the middle line as planned. In the latter case there is no real error; there is more of the foramen magnum to close up on one side than on the other. In the former instance there is certainly some error and it is quite impossible to correct it. The chance of this error occurs very seldom and the magnitude is so small that I have not thought wise to eliminate or even to make a note of the few instances. Carelessness is filling the skull or in transferring water from skull to pan or pan to cylinder would vitiate the result but need not be considered in this work. Professor Davidson Black of Peking was responsible for the origination here of the scheme of measuring capacity in this manner and I would acknowledge the indebtedness which we feel towards him for making the beginning of what has now grown to be an extensive systematic investigation. Except for those skulls of which Black determined the capacity I have myself made the estimates and my readings form the very large majority of the series. I shall discuss later the possible error resulting from the complication of observations made by different workers. For the moment note that both observers are experienced men and almost all the measurements have been made by one person.

Overflow of water into the sinuses may be prevented by care; should it occur the skull is emptied into the sink and the determination started again from the beginning. Efforts are made to avoid water flowing into the venous sinuses but at most this could not modify the result by more than a very few cubic centimeters. The temperature of the water is not controlled for the determination cannot be made with the minute accuracy which this precaution would demand. My secretary, Miss Lindala, who fills out the record at my dictation may, through misunderstanding my words or through an error in my reading, set down an erroneous figure. The great care which we take to have the two readings within 15 cc. of each other eliminates the possibility of this mistake. It is true that in the beginning we were content to accept two readings differing by less than 25 cc. The earlier averages are then probably not quite so accurate as the later ones, but such an improvement in technique as this creeps unconsciously into any work which one may undertake and can therefore be discounted.

The question of errors in record is well worth passing notice. Many, possibly most careful anthropological observers distrust a recorder. They prefer to enter the record themselves, holding that a second person is quite liable to make an error in inscribing the spoken word. Granted that this be so what shall we say of the possibility of an erroneous reading being inscribed by the observer himself. His mind is usually so fully occupied with the problem that subconsciously errors may creep unnoticed into his record. Miss Lindala has been constantly associated with me in nearly all my anthropometric measurements during three years. Her attention is upon the figures, not upon the problem. If for any reason she suspects my reading she draws my attention to the figures. As a result of our experience I am convinced that an interested and alert partner is a very distinct asset and errors are eliminated to a far greater degree than would be possible by the observer working alone.

I know of no other observations upon possible error resulting from this type of technique except the remarks by Macdonell on Thane's crânes étalons (30, p. 204). This writer was willing to accept a difference of 10 cc. but not one of 20 cc. In the latter case Pearson did the repeat determination and from the comment one might reasonably infer that Macdonell's second and aberrant determination would be discarded.

The question which may now be asked is, within what limits can one depend upon the accuracy of this method. Others have claimed for it an accuracy of within 50 cc. That means a maximum error of about 3%. Such an error does not compare badly with the actual (not the claimed) errors of other methods except the observations of Broca himself. Of course it is impossible to determine accurately even the error of the method. In order to conserve space I propose to postpone further statements upon this matter until I come to discuss the determination of capacity after removal of the membranes. This is a more difficult procedure because there may now be some small leaks in the skull from the opening up of foramina.

If then the determination be made upon the fresh skull we must render the results comparable with those carried out on the macerated and dried cranium. Here we have two difficulties to face. In the first place the volume of the membranes must be deducted and in the second a correction must be made for shrinkage of the bones in drying, provided that be found upon examination to be of practical importance. One naturally thinks of Broca's well known experiments upon the influence of humidity on skulls. This matter we shall take under consideration later; at the moment we shall examine the problem of the membranes.

DIRECT DETERMINATION OF VOLUME OF THE DURA

In order to compare properly the capacities of our skulls with those in most other collections, and certainly with those series which we are using as alternative standards by which to check our results, it is imperative to know the average volume of the brain membranes and to add that volume to the capacity ascertained for each of our specimens. In this way we shall obtain a figure representing the total capacity after removal of both brain and membranes, the condition in which most skulls have been measured. Now in removing the brain the pia comes with it and the arachnoid also, except that which remains attached to the dura. Hence for practical purposes it is the real volume of the dura which we propose to investigate.

So far as I have been able to discover very little accurate work has been done upon the volume of the dura. That considerable variation in thickness of the dura exists in different individuals was mentioned by Broca in his discussion on cranial capacity (13. p. 63). According to Vierordt (56) the following figures are given by E. Bischoff for the weight of the dura; a 33-year old male 42 gms., a 22-year female 40 gms. These translated into volume, considering the specific weight of the dura as 1.09 (Pfister 41), correspond to 38.5 and 36.7 cc. respectively. The same authority quotes R. Wagner to the effect that in one skull of 1450 cc. capacity the dura volume was 59 cc.; and Th. v. Bischoff gives the dura volume from a skull of 1455 cc. capacity as being 122.5 cc. This latter value equals 8.42% of the total capacity. Huschke (24) subtracted about 215 gms. e.i. about 206 cc. from the total capacity of the skull in weight of water, for the dura. Pfister gives the dura volume for quite young children of the ninth and tenth months after birth as varying from 28 to 54 cc., in two cases from the third year as 45 and 62 cc. respectively, while one boy in his seventh year possessed a dura reaching the volume of 69 cc. Again quoting Pfister the dura weight in two skulls of the same age may differ, according to E. Bischoff by as much as 40 gms., that is 36.7 cc. From his own measurements and calculations Pfister estimated that it is necessary to add 6.5 to 7.0% to the cranial capacity measured by the water method on the fresh skull in order to determine the full value of the cranial capacity after removal of the membranes, and thus make possible comparison of the figures with those obtained by other methods upon the dried skull.

The foregoing paragraph illustrates the need for revision of our data upon the volume of the dura and an investigation of the conditions which influence this great variation.

Estimation of the volume of the dura can be undertaken by two methods. The first consists in stripping the dura off the interior of the cranium and measuring its displacement in water. The second involves taking the capacity of the cranium after the dura has been stripped out and subtracting from this figure the capacity of the skull when the dura was still intact. At first sight these methods both seem quite simple and liable only to a comparatively small possible error. Nevertheless, to increase our accuracy, we determined to use both and check the results obtained from the one against those given by the other. I therefore set aside fourteen skulls the cranial capacity of which I had just measured with the dura intact. This batch of skulls belonged to the cadavera the dissection of which was finished at the end of March 1922. Of these skulls, seven were male White, three male Negro, two female White and two female Negro. It must be understood that, as usual, the falx cerebri was included in every case. Before I had the opportunity to make the new measurements a student, who did not realize the importance of these skulls, ripped off some of the dura from one half of skull 724 a female White, thus reducing my number to thirteen but fortunately I was able to replace this female skull and to add two more male Whites.

TABLE I.—DETERMINATIONS OF THE VOLUME OF THE ADULT HUMAN DURA BY THE DIRECT METHOD

Skull	Sex	Stock	Age	Capacity (membranes in place)	1st estimate	2nd estimate	Difference
883	M	White	39	1405	54	54	
895	"	"	60	1573	45	45	
896	"	"	53	1417.5	70	70	
897	"	"	32	1475	50	40	10
900	"	"	35	1432	45	55	10
903	"	"	67	1481	50	50	
905	"	"	77	1575	55	50	5
912	"	"	63	1596	65	60	5
939	"	"	50	1461	50	54	4
891	M	Negro	38	1448	35	32	3
906	"	"	35	1389	50	46	4
911	"	"	58	1401	55	55	
886	F	White	32	1298	35	35	
893	"	"	51	1069.5	30	38	8
751	"	"	65	1193	55	50	5
773	"	"	60	1520	40	40	
Average				1421	49.0	48.4	3.4

From these sixteen skulls I carefully removed the dura, a very easy task if the skull be not old. The dura does not adhere much to the base except the basi-occipital and dorsum sellae, until after forty-five years. Beyond this age adherence of the dura to the base becomes greater in

the neighborhood of the cavernous sinus and even the crista galli but in no case was I unable to make a complete extirpation. Having taken care to remove any blood or clot I then submerged the entire bulk of membrane taken from one skull under 500 cc. of water in a graduate cylinder and read the displacement. The figure obtained represents the total volume of the dura for that skull, and is recorded in Table I as the first and second estimates by the direct method. Failure to extirpate completely all the membranes need not be considered but there are two possible errors which must be reckoned with. In the first place it is not quite so simple as one might think to eliminate all bubbles of air from the submerged membranes; I have done my best in each case to avoid error from this source but cannot assure myself that one would be justified in ignoring it. The second source of error lies in the membranes themselves. Sometimes they are exceedingly soft and waterlogged. In each case I have wrung the membranes as free from water as I possibly could before submerging them. In No. 900 especially, however, satisfactory wringing was out of the question because of the softness and slipperiness of the membranes. This softness not only constitutes a source of error in itself but in addition it markedly increases the difficulty of eliminating all air bubbles. I think that these two errors together account in small part for the cases in which the direct measurement seems disproportionately large compared with the results of the indirect method.

I next estimated the volume of the membranes by the indirect method. Having stripped out all the dura I remeasured the capacity of the cranium, taking the mean of two estimations which were within 15 cc. of each other, exactly as is described for the original measurements of cranial capacity and subject to the same errors. From this measurement is subtracted the capacity determined at first when the dura was yet in place. The difference represents the volume of the dura by indirect measurement. But there is an annoying source of error in this method due to the fact that stripping off the dura leaves the skull no longer quite watertight. Sometimes the filling of the cranium with water and transference of the water to the container must be done with considerable haste in order that a minimum be lost. I am inclined to think that those cases like No. 773, where the direct measurement is very large compared with the indirect estimate are instances where this error has appeared. The indirect method proved in practice much less satisfactory than the direct. Although the average result comes reasonably close to that of Table I, yet for individual skulls it is quite un-

serviceable because the figure obtained is the difference between two estimates each of which is liable to a moderate amount of error. In consequence I have not deemed it worth while to insert a special table of the indirect results. The reader can readily obtain them from Table III. One thing which will be observed is the rather curious reliability of results obtained by different observers for calculating the dura volume indirectly. Although my results for capacity with membranes in situ and also for capacity without membranes are considerably higher than those of Dr. Y., yet the difference between my sets of figures and the difference between his sets of figures are closely similar. This of course indicates that the personal factor is the really important one, and the main source of error.

Table I shows an average difference of 0.6 cc. between the two direct estimates. The method is obviously not one which can be relied upon to give a closer accuracy than to within a few cubic centimetres of the real value but it is apparent also that we are not dealing with a problem in which there is a minimum of variation. The dura volume is markedly erratic and the table fully bears out the statements of Pfister regarding dura volume in the child. It also tends to substantiate the remark of E. Bischoff concerning the great difference in dura volume found in two individuals of the same age. The estimates of Wagner and E. Bischoff upon the probable volume of the adult dura were based naturally upon too slender data but the mean of the observations of these two men comes close to the average volume as I have estimated it. The case of Th. v. Bischoff must certainly be an exceptional instance and should not be permitted to vitiate our impression.

From our results one would be justified in taking the average dura volume in the adult as 49.0 cc. or in round numbers 50 cc. In this memoir I shall use the larger number since it is possibly somewhat more exact. But it is now apparent that with certain reservations to be presented later we may compare determinations obtained by the water method on the fresh skull with the observations of other workers by other methods upon the dried skull provided we add 50 cc. to our estimate for each cranium. This amount upon the average cranial capacity of 1421 cc. equals only 3.5%. Now Pfister considered it necessary to add 6.5–7.0% to the amount obtained on the fresh skull. His estimate however was largely based upon the rather high figures given by other workers and on the expectation of fair growth in volume of the dura with age. By comparing Pfister's figures for dura volume in the child with our own it is apparent that there is little or no increase in dura volume after

infancy. Indeed Pfister cites infants of eight months in both sexes with a dura weight of 38 gms. Actually one would not expect much growth in volume of the dura after infancy since by far the greater proportion of cranial growth has already taken place. Our Table I itself shows that age, at least in adult life, has no bearing whatever upon the dura volume. The lack of influence of sex also confirms Pfister's results. Lastly one must not lose sight of the probability that Stock has no influence either.

Now I mentioned that with certain reservations we can compare our results with those obtained by others by diverse technique. The reservations are the correction of the personal error and the correction, if any be needed, for the fact the cranial capacity, in our determinations, has been taken upon a natural (i. e. recent) skull. We therefore take up each of these problems in turn.

THE PERSONAL FACTOR IN THE WATER METHOD

In order to demonstrate the dependence which may be placed in determinations by the water method on the fresh skull I have drawn up two tables, one dealing with the cranium with the dura intact, the other after removal of the dura. The second is especially valuable for it provides a very efficient check upon the influence of different observers upon a relative accuracy of result not otherwise readily ascertained.

TABLE II.—OBSERVATIONS UPON CAPACITY WITH AN INTACT DURA

Skull	1st estimate T. W. T.	2nd estimate T. W. T.	3rd estimate T. W. T.	Average	1st estimate Dr. Y.	2nd estimate Dr. Y.	Average	Difference
883	*1404*	*1406*	——	1405	1358	——	1358	47
903	Of five determinations			1481	Of 3 determinations		1421.6	59
939	1465	1467	1451	1461	1392	1386.5	1389	72
893	1071	1070	1067	1069.5	1035	——	1035	34
911	Of five determinations			1401	1365	1345	1355	46
				Average difference between T. W. T. and Dr. Y.				52

Table II gives data for reliability of the method, the dura being intact. This naturally includes the falx cerebri which is always left fixed to the tentorium. In three of the cases each estimate, as usual, represents the mean of two determinations which in my own case do not differ by more than 15 cc. From the figures here given it will be seen that one observer of experience can hope for results which will give a probable constancy within about 1%. My largest deviation in successive estimates is shown by No. 939. In this skull the mean capacity is 1461 cc. and the maximum difference is 16 cc., slightly under 1.1% of the average capacity. Broca claimed for his own results a variation of about 0.3%, and for

other workers with his method about 0.7%. Hence, in view of its simplicity and ease the water method compares quite favorably with the best results obtained by other methods.

The water method however requires a technique which must be learned. To illustrate this I asked a colleague, whom I shall call Dr. Y., to check my results. Dr. Y. gets a mean result upon the series less by 52 cc. than mine. This difference brings fully into recognition the one most important feature of the technique. I think after consideration of all the results which are critically examined in this memoir it will be admitted that my determinations are probably more nearly accurate than these which give, in general, a smaller value. What then is the cause of the consistently lower values obtained by Dr. Y.? The care with which these results were obtained is strikingly shown by the fact that after the dura was removed Dr. Y's., results were again consistently about 50 cc. below mine (Table III). Each of us made the determinations without previous discussion of details of the technique. Dr. Y. desired above all to avoid water overflowing into the nose and paranasal sinuses and therefore scarcely employed the full volume of water which the cranium can hold. On the other hand I was desirous of giving the fullest possible value, but still avoiding overflow into adjacent cavities, bearing in mind the possible loss of volume entailed by the saw cut. Now in an elliptical layer one millimeter thick, of length 180 mm. and breadth 114 mm. there are about 17 cc. by volume. Applying this to the cranium with its irregular outline we should not be far wrong if we estimate about 25 cc. per millimeter of saw cut, and it is quite possible that the saw cut interferes to rather more than this extent. Hence it is the last 50 cc., so to speak, which is in question.

THE NATURAL CRANE ÉTALON

The suggestion which presents itself at this stage is the question whether determination of capacity after the skull has been bisected is a reliable estimate of the capacity of the intact skull. This question is if anything more acute in the case of the dry crâne étalon usually constructed by sawing the skull in two, rendering both halves watertight and cementing them together again. Such a technique, like that adopted in the present work, involves a possible error of the last 50 cc. and yet it is not practicable to render the skull really watertight without bisection. Ranke's Bronzeschädel is also conceivably subject to the same error though of this I cannot be sure for I have never seen one and I do not know the exact technique of making the original cast. The possible

error of the last 50 cc. may be avoided however since it is quite possible and indeed simple to make a natural crâne étalon out of an ordinary fresh skull. The only preparation needed is the flushing out of the entire brain, pia and arachnoid under a powerful jet of water. Provided one be assured that there are no remnants of the soft brain left in situ the only possible errors come from the presence of air pockets and the difficulty of draining all the water out of the skull. One might measure the water as it is poured into the skull but this would not really enhance the accuracy for if the water were not thoroughly drained out each time the succeeding determination would be just as inaccurate as if the contained water should be measured after being poured out again. Dura and especially fresh dura has a curious habit of retaining the last few cubic centimeters of water in any case. The trouble which other workers have encountered either with crânes étalons or with Bronzeschädel is the occurrence of air pockets. I have not found it possible to pour water into such a contrivance without losing some in consequence of my attempts to drive the air out of the pockets. Further I am not aware that in either of the types hitherto used there has been any provision for eliminating air through other foramina than the foramen magnum through which the water is poured in. The natural skull has a distinct advantage from this point of view since the carotid arteries form excellent air valves permitting the escape of air without interfering with the water content.

In order to solve the problem to which I alluded above I have used a fresh skull as a crâne étalon and must present the result of the inquiry. Skull 952 was employed for this purpose. It is a large German head of more than average cranial capacity. The term natural crâne étalon should be explained. Later I shall have occasion to refer to shrinkage of the skull in drying. In former investigations by Broca and Welcker upon the effect of a state of humidity upon cranial capacity and linear dimensions the problem was to determine how much the capacity or dimensions would be increased by soaking the skull in water or subjecting it to a humid atmosphere. These workers were therefore justified in referring to a wet or soaked skull. The problem which I have to deal with is the converse. One cannot speak of the living, fresh, or even the recent skull as wet or soaked: it is in its natural state, reproducing for practical purposes the condition met with during life. When I speak of the skull before maceration and especially when I refer to the fresh skull even before embalming I shall define it as the natural skull.

The natural crâne étalon is then a standard skull produced by the

simple expedient of flushing out the brain from the skull of a cadaver otherwise not interfered with since death. It has never been embalmed.

Mr. Leonhart prepared for me in this manner the male white skull No. 952. He had some difficulty in assuring himself that no vestige of the brain remained owing to my request that he leave intact the tentorium. He was also a little doubtful as to whether some of the cranial nerves remained inside. However the sequel showed that in both these matters he had been entirely successful. Neither brain tissue or nerves before their entrance into the dura were found when the skull was finally bisected.

I have tabulated below the results of our investigation on this skull, each estimate being the mean of seven determinations.

Skull 952, male, White, German, age 40 years

Cranial capacity, skull and tentorium intact	1509.5 cc.
Cranial capacity, skull intact, tentorium cut	1586.5 cc.
Cranial capacity, skull bisected, falx still in situ	1591.0 cc.
Cranial capacity, skull bisected, membranes removed	1646.5 cc.
Volume of dura by displacement in water	67.0 cc.

In carrying out the work I found an unexpectedly high degree of difficulty in eliminating air from the cranium and in removing all water between determinations. In fact I am certain that about 10 cc. constantly remained in the skull. The difficulty was much greater while the tentorium was intact and the table shows how unreliable is a determination of capacity so long as the tentorium remains untorn. Actually the maximum range of variation for the seven determinations with tentorium intact was only about 40 cc., the same as that in the second set of observations after rupture of the tentorium.

No difficulty occurred from leakage; the skull remained watertight until the dura itself was torn out to permit of the fourth series of determinations.

Comparison of the second and third sets of measurements completely vindicates our assumption that capacity determined on the bisected skull is a correct estimate of the actual capacity. The means of these two series of experiments differ by only 4.5 cc.

The direct estimate of dura volume has already been discussed and we are about to consider cranial capacity after removal of the dura and the possibility of estimating dura volume indirectly by subtracting the capacity with dura intact from the capacity after removal of the dura. As a rule for individual cases we shall find the indirect not so trustworthy as the direct method of estimating dura volume but in this instance I regard the indirect estimate as more reliable, in the first place because each estimate is the average of seven determinations instead of two and

secondly because it was impossible in this case to express all air and free water from the fresh dura itself. After the embalming process the dura is much less slimy and soft and therefore easier to deal with.

The foregoing experiments were carried out upon a skull of considerable dimensions. In order to check the reliability of the conclusions drawn from skull 952 we decided to treat in the same way skull 954 of different sex and stock and very different capacity. The only change made in the routine examination of this second natural crâne étalon is the elimination of the useless series of determinations with tentorium intact. Our results are the following, each estimate again being the mean of seven determinations.

Skull 954, female, Negro, age 24 years

Cranial capacity, skull intact, tentorium ruptured	1115.4 cc.
Cranial capacity, skull bisected, falx still in situ	1119.7 cc.
Cranial capacity, skull bisected, membranes removed	1173.4 cc.
Volume of dura by displacement in water	59.3 cc.

No loss of water occurred from leakage : the difference between maximum and minimum figures for the first series of determinations was 20 cc.; for the second 34 cc.; for the third 23 cc. and for the fourth, 10 cc. For the last the sliminess of the fresh dura is directly responsible. The difference between the means of the first and second series of measurements is only 4.3 cc. For this skull the volume of the dura as estimated indirectly is 53.7 cc. as against 59.3 cc. by the direct method as carried out in the body of this work.

The results of this second experiment fully confirm those with the former natural crâne étalon and render redundant any further experimentation along this line.

In summary then we conclude that in practised hands the bisected skull gives an estimate of capacity quite within the accuracy of our technique as previously described, that is to say varying less than 16 cc., from the true capacity.

DETERMINATION OF CRANIAL CAPACITY AFTER REMOVAL OF THE DURA

It is only after the dura has been removed that one can realize how porous are the cranial walls. If the external soft tissues are also stripped off, the cranial walls constantly drip water which is percolating through. In addition the act of removing the dura is apt to open foramina. In many of the skulls to which reference is made in Table III this certainly happened. One learns however to cut off the nerves at their exit and the dura round the margins of the foramen and thus to avoid the formation of resultant holes. There may be a certain slight loss of volume

in the measured water consequent upon retention of some by the bone. But this cannot amount to more than one or two cubic centimeters for the skulls are kept thoroughly soaked under water between the determinations. Indeed if there is any error resulting from water in the bone I should rather expect it to be an increase of one or two cubic centimeters from water draining into the pan from the bone in the final shake which is given to the emptied half-skull. In any case error from this source is quite negligible.

TABLE III.—OBSERVATIONS UPON CAPACITY AFTER REMOVAL OF THE DURA

Skull	Capacity Dura intact	1st estimate T. W. T.	2nd estimate T. W. T.	Average	Volume of Dura (indirect)	1st estimate Dr. Y.	Difference between T.W.T. & Y.
Male White							
883	1405	1452	1459	1455.5	50.5	1397	58.5
895	1573	1628.5	1645	1636.7	63.7		
896	1417.5	1484	1518	1501	83.5		
897	1475	1509	1548	1528.5	53.5		
900	1632	1648.5	1659	1653.7	21.7		
903	1481	Of 5 determinations		1518	37.0	1481.6	36.4
905	1575	1620	1614	1617	42.0		
912	1596	1669	1673	1671	75.0		
939	1461	1516	1531	1523.5	62.5	1467.5	56
Male Negro							
891	1448	1486	1492	1489	41.0		
906	1389	1417	1444.5	1430.7	41.7		
911	1401	Of 5 determinations		1445.6	44.6	1416	29
Female White							
724	——	1215	1214	1214.5	——		
886	1298	1366	1355	1360.5	62.5		
893	1069.5	1119	1111	1115	45.5	1075	40
935	——	1200	1203*	1203.5	——	1138.5	65
Female Negro							
751	1193	1257	1281	1269	76.0		
773	1520	1540	1512.5	1526.2	6.2		
			Average		50.4		47.5

*Third estimate 1207.5

From Table III it is apparent that one must not expect the same constancy in determination of volume upon successive trials which one can reasonably count upon in the case of the skull with dura intact. The porosity of the bone and the opening up of small foramina account fully for this. Each estimate, as before, is the average of two observations. The mean of the two estimates (that is of four determinations) however, probably gives a fairly close approximation to the true value of the average even over a small series. The average cranial capacity of the sixteen skulls on which determination could be made with dura intact amounts to 1434.6 cc.; the mean capacity of these same skulls after removal of the dura is 1483.8 cc. This gives a figure of 49.2 cc. for dura

volume which will be considered in the next section. At the moment we are concerned simply with the constancy of result. Instead of a maximum difference of 16 cc., between estimates, as in skulls with dura intact, we now find a maximum difference of almost 40 cc., although this is rare. Nevertheless the mean of the estimates for each skull is probably close to the true value, for the difference between Dr. Y's estimates and my own on six skulls approximates the personal error as determined in the skulls with dura intact (Table II.). There it will be remembered Dr. Y's average fell 52.0 cc. below mine. Summing up one may say that, although for reasons previously stated, determination of capacity in the fresh skull after removal of the dura is more difficult than measurement on the cranium with dura intact, the personal factor remains the same and the method is dependable in somewhat less degree.

INDIRECT ESTIMATES UPON VOLUME OF THE DURA

In the two foregoing sections it has been necessary to refer frequently to indirect estimates upon the volume of the dura and these statements leave nothing to be stated now except the fact that the indirect method is not advisable on account of its relative inaccuracy for individual skulls. Nevertheless one may obtain by it a fairly close approximation for the average dura volume even upon a short series. More detailed information regarding the possible error in determinations of capacity upon the skull will be given in the section dealing with reliability of the technique of the water method. One may state here that the results later set forth show a possible error of 16 cc. in individual cases with dura intact and of as much as 40 cc. with dura removed. It is obvious that results of this kind cannot be used to determine volume of the dura itself which we have seen to be in the neighborhood of 50 cc.

In spite of its relative unreliability for determination of dura volume in individual skulls, the indirect method gives a fairly close approximation of the probable true mean value of dura volume taken over a small series. Thus the direct estimate gives an average dura volume of about 49 cc. upon a series of sixteen skulls of varying age, sex and race; whereas the indirect method gives a mean determination of 50.4 cc. for the same sixteen skulls if the individual results are used. If, instead of this method one averages the total capacity with dura intact and with dura removed the mean volumes 1434.6 cc. and 1483.8 cc. are obtained respectively for the series of sixteen skulls. Subtracting the former of these figures from the latter one obtaines a mean dura volume of 49.2 cc. which is sufficiently close to the figure obtained by other methods

of procedure. In conclusion one would remark that for even a small series either direct or indirect method will give a mean result not far from the probable true mean but for individual skulls there is no doubt that the direct method is much more reliable and will give a result probably accurate within 3 or 4 cc.

RELATION OF CAPACITY IN THE FRESH SKULL TO THAT OF THE SAME SKULL DRIED

We now come to the consideration of a possible source of error which may have a very marked influence upon our results, namely the effect of drying upon the capacity of the skull. The question which we have in mind is how far we are justified in assuming that the capacity estimated when the skull is dry represents the actual capacity in the living condition.

Broca was much impressed by the conclusion of Welcker, to which we must give careful consideration later, namely that the linear dimensions of the skull do not alter sensibly with the state of humidity of the skull; yet he could not help being influenced also by the evident fact that considerable changes may take place in the form of a skull after burial. Such a skull, as is well known, may exhibit considerable warping and even gaping of sutures. Now, having substantiated a probable error of not more than 5.0 cc. by his technique of capacity determination, Broca set himself to make a thorough investigation of the influence of humidity upon volume of the cranium (14). Broca employed only long dried skulls; estimated their capacity, subjected them to various degrees of humidity and determined their capacity anew. As a result Broca found that such slight dampness as may occur from seasonal changes in humidity has no apparent effect upon volume; but thorough immersion of the skull in water for one or two days has a pronounced effect equally well marked in the adult skull of all ages notwithstanding differences in extent of closure of the sutures. Two days' soaking of three skulls with sutures more or less closed gave an average increase in cranial capacity of 43.3 cc. A single day's soaking only increased the capacity of the same three skulls by 33.3 cc. Immersion for three days of three skulls of which the sutures were ununited gave an average increase of 39.0 cc. Stated in percentages of the dry capacity these results are respectively 2.99%, 2.29% and 2.66%. These results are very different indeed from what Welcker indicates. It is true that the difference is not greater than the error which most methods would permit in the hands of most investigators. Nevertheless it is a source of error which can be allowed for and

therefore it seemed wise that we should reinvestigate the problem. Our observations upon linear dimensions will follow in an appropriate section of the memoir. At the moment we are concerned with the influence of drying upon capacity.

A complete and final statement of the influence of drying upon capacity can only be made upon material which has been carefully measured and checked throughout the long and pre-arranged investigation. Such a study is at present in progress, but a fairly shrewd estimate of this factor can be presented at once. The investigation is prolonged for Broca has shown that the increase in capacity does not occur promptly upon immersion, nor the return to the original volume take place until many weeks after the drying is apparently completed. In this estimate an accurate knowledge of the dura volume for the particular skull in question is essential. Although we have this information upon many of our recent skulls the skulls themselves will not be in condition for the final determination of capacity for some months. Notwithstanding this drawback we can obtain sufficiently accurate results for our present more general purpose by using skulls of which we do not know precisely the dura volume.

For this purpose I have chosen three male white skulls of various ages. The capacity was determined fresh with the dura intact and after a sufficiently lengthy period of drying in the atmosphere of the Museum during the winter when there was a high degree of artificial dry heat, these skulls were prepared for a new determination of capacity by the same water method the details of which have been given. The interior each half of the skull was rendered completely water proof by a layer of Martin's celluloid cement, (32, p. 32), one of the most useful adjuncts to an osteological collection. The composition of this cement is the following: Amylacetate 70 parts, Benzole 70 parts, Acetone 35 parts. In this solution dissolve shredded celluloid until of the consistency of thick syrup. The various foramina were closed with plasticine after the celluloid cement was thoroughly dry. It should be added that the celluloid, being quite transparent, does not interfere in the slightest with future detailed observation of the coated area. Five determinations of capacity were then made upon each skull and the mean in each case compared with the mean of determinations carried out upon the fresh specimen with dura intact. Table IV gives the actual figures obtained for all the skulls. From this table one notes the remarkable fact that the average capacity of the three skulls in the recent state with the dura intact is 1448.3 cc. and the average capacity of the dried skulls without

the dura is 1438.5 cc. There is then only an average difference of 10 cc., this however does not represent the real shrinkage for we have already seen that the average volume of the dura is about 50 cc. We ought there-

Table IV.—Shrinkage of capacity during drying

Male White skulls after thorough drying, prepared with celluloid cement and plasticine, measured by water method with old apparatus (Fig. 1).

Skull	Capacity dura intact	Estimates of capacity 1st	2nd	3rd	4th	5th	Average	Original cap. + 50 cc. i. e. dura	Shrinkage
856	1337.5	1340	1335	1334	1343	1338	1338	1387.5	49.5
865	1462.5	1436	1450	1438	1458	1436	1443.6	1512.5	68.9
878	1545	1536	1520	1548	1530	1536	1534	1595	61.0
Average	1448.3						1438.5	1498.3	59.8

fore to subtract the average dry volume, not from the average capacity with the dura intact, but from this latter figure corrected for the volume of the dura, that is 1498.3 (1448.3 + 50). This correction would give an estimate for shrinkage of about 60 cc. It may well be that this figure must be corrected when we have more data to draw upon (the smallest shrinkage, namely 49.5 cc. occurred in the absolutely water proof skull) but for the moment, allowing for possible error in technique we must admit a shrinkage of some 50–60 cc. in capacity during drying. The obviously important inference is that shrinkage in drying practically compensates, within the limits of accuracy of the technique, for the volume of the dura. We shall see later that it is inadvisable to substitute the linear measurements of the dry skull for the same measurements on the living or wet skull, but it is permissible to consider the capacity of the dry skull as fairly representing the capacity in the living, provided the living capacity refer to the volume of the brain and its adnexa not including the dura. Thus, our capacity determinations made upon the natural skull with dura intact are quite comparable with the determinations made by other workers upon the dry skull.

A further detail of the investigation of cranial capacity by the water method in dry skulls calls for passing comment. We do not know how soon after immersion the capacity of the skull begins to augment and we are anxious to ascertain if possible whether our technique was sufficiently perfect to avoid any possible error from this source. It will be shown later on that Welcker was mistaken in asserting that no appreciable change takes place in linear dimensions of the skull in drying or

immersion. It is also true that there was a slight leak from the mastoid region of skulls 865 and 878 though not from skull 856. This may account in part for the smaller volume relative to the capacity in the natural state exhibited by these skulls. In order to assure myself that no error had crept in through the augmentation of volume during the time occupied in making the five determinations I measured the linear dimensions afresh some thirty-six hours later when the skulls had thoroughly drained. This delay is in accordance with Broca's observation that a considerable time must elapse before the full effect of soaking becomes evident. The results of this control are compared with the original measurements in Table V which shows that I am justified in believing no change to have occurred during the work. This means that the celluloid cement was indeed water-proof and that no water soaked into the cranial bones generally to alter their constitution.

TABLE V.—SHOWING ABSENCE OF SWELLING IN LINEAR DIMENSIONS DURING OPERATIONS FOR TABLE IV.

Skull	Age	Dried*	Length	Breadth	Aur. Height
A. Original measurements dried skull. Old apparatus Fig. 1.					
856	23	86 days	173	136	116
865	50–55	77 days	186.5	143	112
878	55	89 days	180	148	119
B. Celluloid—Plasticine—Water method again—Drained thirty-six hours					
856			172	135.5	116
865			186.5	144	112
878			180.5	148.5	119

*The period of drying indicates the number of days between maceration and the date upon which the figures in section A were obtained.

ACCURACY OF CAPACITY DETERMINATION BY THE WATER METHOD

On a previous page I have discussed the possibilities of error in the actual carrying out of the determinations and further on I have demonstrated the need for previous agreement between two observers whose work is to be compared concerning the precise object to be attained and the details of technique to be employed. The problem which faces us now is the major one of constancy of observations upon capacity made by a single observer. If he repeat the observations on another occasion how close will the character of the technique permit the second result to approximate the first. An absolute value may be obtained for the

capacity of a single crâne étalon and this can serve as an index for the probable accuracy of determinations upon other skulls but it does not necessarily standardize them. No value can be other than relatively correct and therefore it would seem to me that no amount of attention to a single crâne étalon can give the confidence which will result from the re-investigation of a series of skulls and the comparison of these second determinations with the former ones.

Now the reliability of determinations upon capacity will naturally depend somewhat on the ease with which the technique is carried out: where there is possibility of a leak the reliability will be less than where there is no leak. Upon this basis determinations may be assorted into three groups according as to whether the skulls have the dura intact (and there are no bullet holes); whether the dura has been removed, there being in this case a tendency for slight leakage through minute foramina; or whether the skull is dried and treated with celluloid and plasticine, a method theoretically perfect but actually not invariably so.

Table II gives the results of an examination into the relative constancy of observations upon capacity in the first group with dura intact. For this purpose we shall consider only those estimates made by myself. Each estimate as always is the mean of two determinations which themselves differed by not more than 15 cc. It is not a difficult matter to obtain such results provided care and patience are employed but we must know how nearly the mean estimate can be reproduced upon another occasion. Between estimates on successive days Table II shows a minimum divergence of 2.0 cc. and a maximum of 16.0 cc. We may take it therefore that the accuracy of the estimate on capacity of any particular skull lies somewhere between these limits, the average divergence being about 7 cc. This is not so accurate as the result claimed by Broca although the average divergence is like Broca's difference, only about 0.5%. One would undoubtedly be safer in concluding that the maximum divergence of 16cc. (about 1.2%) gives the probable accuracy of the technique.

We now turn to the second group, in which the dura is removed. The data for this series are given in Table III. Again we take only the difference between my own estimates. The divergence between first second estimates varies all the way from 1.0 cc. in No. 724 to 39.0 cc. in No. 897. There is no apparent reason for the comparatively large divergence in the latter skull. There is also a large divergence in Nos. 896, 906, 751 and 773. The reason for the large individual divergence in this series compared with the individual divergence in the series with

dura intact is undoubtedly the opening up of the small leaks by removal of the dura. In spite of the relatively large possible individual discrepancy the average divergence in this series also amounts to about 16 cc.

The third group of observations shows once more somewhat less reliability than the first. The skulls in question were dried, rendered waterproof and again examined. The results are given in Table IV. There are only three skulls in the series and of these only No. 856 proved absolutely without any leak. This skull gives a maximum divergence of only 6.0 cc.; Nos. 865 and 878 give a divergence respectively of 22.0 cc. and 28.0 cc. and the average divergence is 18.0 cc. The actual condition relating to possible leaks is approximately the same in this series as in the second series in which the dura is removed.

The conclusion to be drawn from the foregoing investigation is that, whether the capacity is determined after removal of the dura or after drying and rendering waterproof, the result will be liable to an error probably not exceeding 40 cc. in individual cases but that the average reliability over a considerable series will be much greater than this and even in a small series will be within 20 cc. of the real value. Undoubtedly the most constant results are obtained by measuring capacity in the fresh skull with dura intact although here the reliability for individual cases should be taken as correct only to within some 15 cc. or 1.0%. By this method the average reliability over even a small series may be within 7.0 cc. or 0.5%.

CRANIAL CAPACITY OF THE RESERVE MATERIAL

In the foregoing parts of this communication it has been shown that the observations as carried out in Cleveland by the water method upon fresh crania are constant to within 16 cc., roughly 1.0% of the total capacity; that they are probably accurate to within 5.0 cc. of the absolute capacity as shown by the experiments with the fresh crâne étalon; and that, since the shrinkage of the skull in drying reduces cranial capacity by an amount practically equal to the volume of the dura, the observations are comparable with the results of other workers upon dried skulls. These facts having been assured it is possible to discuss the cranial capacity of our material in the light of other series.

During the past winter Miss Margarat Russell has been employed in reducing mathematically the observations which I have made on material accruing to the laboratory since 1914. This investigation has formed part of Miss Russell's work leading to the degree of M.A. All the reductions have also been carried out by myself; and in those in

which Miss Russell had no part, my work has been confirmed by Miss Lindala, by Mrs. Todd or by my son Arthur. Hence every step in all the laborious calculations has been carried out and all figures have been vised by two individuals whose results absolutely check. This must be understood to refer to all the mathematical work throughout the memoir. I do not think there is any error in actual calculation. As for the original observations they were made by me with the exception of a few of the earlier cranial capacities which are the work of Dr. Black. Any failure, if such there be, is then due entirely to me and not to any one of those who have given generous help in the course of the investigation.

It must be realized that the conclusions drawn in this memoir are by no means final. They should be regarded as the opening up for study of the rapidly increasing anthropological collection in the Hamann Museum. So fundamental a measurement as cranial capacity has proved to be in anthropological work justifies the temporary use of small and even merely suggestive series like that of our female Negroes. Within a few years the smaller series will have grown to sizeable numbers, speaking in terms of the usual anthropological collections. By then the larger series will be far beyond anything hitherto attainable for this work. But meantime it is essential to have a working basis for other aspects our anthropological research. This is our justification for the presentation of such results as we have already obtained.

In Table VI, I have given the mean capacities of our White and Negro material with the standard deviations, coefficients of variability and errors and have compared the results with the figures given by Lee and Pearson for various White races (28) and with those given by Benington and Pearson for certain Negroes (6). For the size of the Negro series I have used the total numbers given in Benington's paper and not those later stated by Isserlis (25). There are some rather valuable conclusions to be drawn from this table.

The German series used by Lee and Pearson are Ranke's Alt-Baierische collection which may be taken as a series fairly representing the mediaeval Bavarian population of the country-side. It is a rather homogeneous series. Our own Whites are as heterogeneous as could be imagined for they consist of the human flotsam which has drifted west, some from the British Isles but vastly more from the countries along the North Sea and the Baltic from the Rhine to Riga and the hinterland back to the Danube. I am not absolutely sure that our female population (and by population I mean the material of the laboratory upon which alone our views are built) is the same as the male. There are

TABLE VI.—CRANIAL CAPACITIES OF RESERVE MATERIAL COMPARED WITH THOSE OF THE MATERIAL USED BY LEE AND PEARSON, AND BY BENINGTON.

Race or Stock	Sex	Number	Mean capacity	Probable error	Standard deviation	Probable error	Coeff. of variation	Probable error.
			Reserve material					
White	M.	167	1391.08	± 6.136	117.58	± 4.339	8.45	± .297
White	F.	31	1231.93	±15.302	126.32	±10.792	10.25	± .886
Negro	M.	87	1350.25	± 9.267	128.16	± 6.543	9.50	± .490
Negro	F.	17	1220.70	±20.278	123.96	±14.164	10.15	±1.158
			Lee and Pearson's material (28).					
German	M.	100	1503.72		116.890		7.773	
German	F.	99	1337.15		108.730		8.131	
Aino	M.	76	1461.64		100.605		6.883	
Aino	F.	52	1307.69		89.751		6.864	
Naqada	M.	69	1386.6		104.36			
Naqada	F.	98	1279.3		94.03			
			R. Crewdson Benington's Negro material (6).					
Batetela	M.	47	1343.91	±12.45	126.57	± 8.81	9.42	± .66
Batetela	F.	21	1205.88	±15.85	107.68	±11.21	8.93	± .94
Gaboon 1864	M.	49	1380.51	±10.38	107.69	± 7.34	7.80	± .53
Gaboon 1864	F.	43	1231.70	±13.03	126.63	± 9.20	10.28	± .76

some features about the females which seem to indicate an older American stock but the discussion of this problem must be reserved for a future occasion. The consequences of the difference in homogeneity between our material and Ranke's Bavarians will become increasingly evident but the rather striking difference in mean capacity is certainly not due to degree a racial purity. Lee and Pearson give a mean capacity for the male of 1504 cc.; the mean capacity of our male White material is only 1391 cc. We have already noted that it is quite proper to compare these two series, having regard to the methods of determination of capacity. The difference in capacity cannot be attributed to difference in technique in this case although it is true that technique has usually been to blame for at least part of the discrepancy between the conclusions of various observers. In the later parts of this work it will become increasingly apparent that we have here a real difference and the origin and production of the difference in capacity will become evident. Between these two series the difference of the means is 113 cc. and the probable error of this difference is 15 cc. (For method see 65, p 346). Between the corresponding female series the difference of the means

is 105 cc. and the probable error 25 cc. There is no doubt therefore about the reality of a fundamental difference between the two groups of crania. Now it is also rather significant that the male Bavarians show a capacity 8.1% greater than our male Whites, and the female Bavarians show a capacity greater by 8.5% than the mean of our female Whites. Our material is certainly not representative of the average population of the city. It is a shiftless population recruited from the water front, the criminal districts and the underworld. Interpreted in this manner and compared with the average country-side population of old Bavaria it gives a suggestive indication of the effect of the selection of crime, drunkenness and poverty. We are also impressed with the pronounced influence of selection of one kind or another upon the mean capacity as established by different workers. The startling divergences in mean capacity apparently referring to samples of the same race, which so thoroughly aroused the attention of Welcker and other investigators and have been partly responsible for discouraging work on cranial capacity, are undoubtedly due in part to differences in the sample. This emphasizes the prime importance of sparing no pains to obtain and publish all data respecting the origin of the sample in question and the necessity of studying the probable influences at work in its selection.

Turning to the Negro figures we find an entirely different kind of selection at work. Our material is much more truly representative of the general Negro population in America than is the case with our White material. Here we are dealing with a problem, not of crime and moral obliquity, but of misfortune and hereditary disadvantages. In the later communications we shall find ample confirmation for this thesis. If upon general principles which cannot be fully discussed at this juncture, the point be conceded, we are enabled further to consider the relation of our Negro series to the various African groups hitherto studied. I have expended a good deal of effort with quite unsatisfactory results upon the problem of the precise African origin of our Negro population. Various scholars who have devoted thought to the origin of the American Negro have been able to produce merely scanty and comparatively worthless evidence. Hawkins' journals give little help and I am not at all clear as to from how far along the coast of West Africa and how far into the interior our Negroes came. The more I think of this problem however the less do I come to value the result of the investigation. There is no doubt that a great mixture of native types and races had taken place in the very areas from which of necessity our Negroes must have come. In the beginning the American Negro

undoubtedly belonged to quite as heterogeneous a group as the Whites who have voluntarily followed him to these shores during the past century. The physical characters of our Negroes show plainly that they came from West Africa and not from North Africa or from far south of the equator. A much more significant question, and one more promising of settlement than original African areas, is the condition of the Negroes after arrival in the West Indies. One would like to ascertain how greatly they mingled their blood with that of other races especially of the Whites, and again, what effect contact with the White man or, if one please so to term it, civilization, has had upon their physical characteristics. On another occasion I hope to take up these points seriatim but this is too early in the investigation to deal with the problem usefully.

The best material with which to compare our Negro series consists of the Batetela crania in the Museum of the Royal College of Surgeons, London, and the Gaboon series brought by Du Chaillu to the British Museum from Fernard Vaz in 1864. The former come from an area of some three or four square miles in the east central part of the Congo Free State about 24° 20′ E. and 4° 50′ S. These are notes given to Doctor Benington by Professor Keith; there are no data regarding the Gaboon series in Benington's paper. Instead of a marked difference between the means such as we have found in the case of the Whites, our Negro mean falls between those of the two Negro series now being compared. The difference between the means of our material and the Batetela males is only 6 cc. and the error of this difference 23 cc. For the Gaboon and our males the difference in mean capacity is 51 cc. but the probable error of the difference is 21 cc. The corresponding differences in the means of the females are 15 cc. for the Batetela with an error of 38 cc., and the difference of 10 cc. for the Gaboon with an error of 36 cc. In no case therefore is there any significant difference. Not one of the series is really large and the female groups are merely included to complete the suggestiveness of the survey. It is apparent that all these groups of crania come essentially from the same people, that our series is fairly representative of the population at large, and that contact with the White man, and even the formation of hybrid material, over three hundred years has not in the slightest obscured the plainly Negro characters. The extraordinary similarity between our Negro males and the Batetela males in mean capacity, standard deviation and coefficient of variability cannot pass unnoticed. We shall see later that the American Negro has a longer and rather higher head than the Batetela and

in these respects approaches the Gaboon group. Therefore the close similarity with the Batetela in the table must not be over stressed; it is interesting but not necessarily significant.

Before leaving this section one must comment upon the rather striking way in which our own figures confirm the predictions made by Pearson in 1912. In the course of his discussion of the Negro cranial capacity (6) Pearson says, "I think we may say provisionally that for the Negro skull the capacity is about 1350 for males and 1230 for females . . ." In our moderate series of 87 males the mean capacity is 1350.25 cc. and in our very small series of 17 females the mean capacity is 1220.70 cc.

II. The Mathematical Calculation of Cranial Capacity

THE PROBABLE VALUE OF COMPUTATION OF CRANIAL CAPACITY

We have just noted the rather striking results of comparing capacity in our Reserve material with capacity in various other series, and we have fully observed the technical difficulties of directly determining capacity which greatly increase if the skulls to be measured are already dry. The earliest workers on cubage were fully aware of these unwelcome facts and therefore the effort to devise a mathematical method of obtaining capacity is almost as old as cubage itself. Let us for a moment consider the possibilities.

The cranium is a non-geometrically shaped case, more or less roughly spheroidal, the spheroid being deformed mainly by the addition of the cerebellar fossa. If we have the linear dimensions of a spheroid body it is possible to determine the volume. In addition to some irregularities of the spheroid itself the cranium presents two obvious difficulties, namely the cerebellar fossa and the thickness of the cranial walls.

In 1899 Guiffrida-Ruggeri published an investigation of the volume of the cerebellar fossa (21). His method was very similar to that of Broca. He plugged the foramen magmun and filled the fossa with shot. In a series of 252 male and 268 female crania from individuals of very different height and build Guiffrida-Ruggeri found the mean value of the male cerebellar fossa to vary from 103.5 cc. to 126.8 cc. and in the case of females from 99.2 cc. to 112.7 cc. These mean differences, which at a maximum, amount to 23 cc. for the males and 14 cc. for the females, while relatively large, do not make for a correspondingly large error in the computation of capacity for the entire skull. Of the various errors to be encountered in such a computation at least some will tend to counteract each other. If the constant which obviously must be required include a value somewhere near the mean of all cerebellar fossae for one sex the influence of the possible cerebellar error on the figure for the entire skull will not be great.

Now the problem of thickness of the cranial wall presents no insuperable difficulty; indeed the influence of thickness may often be ignored. Isserlis in 1914 worked out this problem (25) and showed that a difference of 10 cc. corresponds to a difference of $\frac{1}{3}$ mm. in thickness. Consequently this difference can be allowed for should it prove to be necessary.

There is then no inherent impossibility in developing a method of computating cranial capacity; it should be no harder than actual cubage. The essentials are in the first place reliable data from which to develop the method and in the second, a treatment in accordance with mathematical theory and not mere guesswork. We must therefore examine what has been done in this line.

HISTORICAL SURVEY OF THE MATHEMATICAL COMPUTATION OF CRANIAL CAPACITY

So far as I have been able to discover, Parchappe was the first to attempt an approximate estimate of the volume of the head or skull by mathematical computation (37). This work was published in 1836, the year before Tiedemann's famous treatise (50). Parchappe made no effort to form an exact estimate of capacity and curiously enough he never refers to volume as determined directly by Soemmering's investigations on the skull. Parchappe's introduction to his mathematical method is of sufficient historic interest to quote rather fully. Its main points are the following:

"Mesurer la tête de l'homme avec une exactitude absolue, c'est une chose à-peu-près impossible et que je n'ai pas tentée.

"Pour apprécier le volume de cette partie du corps humain de manière à ce que les observations particulières aient la valeur de faits scientifiques, deux conditions sont nécessaires: il faut d'abord que les mesures soient assez nombreuses et comprennent assez d'éléments du volume pour qu'on puisse les considérer comme exprimant très-approximativement ce volume; il faut ensuite que ces mesures soient comparables.

"Ces deux conditions m'ont paru se trouver réunies dans la méthode que j'ai adoptée pour la mensuration de la tête. . . . . . .

"L'ensemble de ces mesures rigoureusement déterminées, et, par conséquent, comparables, me paraît pouvoir être considéré comme exprimant d'une maniére suffisamment approximative le volume de la tête.

"Je pense que les observations dans lesquelles ces mesures ont été déterminées, constituent des faits scientifiques, d'où peuvent être tirées des inductions légitimes.

"Un plus grande nombre de mesures pourrait conduire à une approximation plus grande. Mais la difficulté de déterminer rigoureusement des points fixes de départ pour les mesures, quand ces points sont arbitrairement pris et ne sont pas en quelque sorte indiqués par la nature elle-même, est une source d'erreurs presque inévitables; et cette considera-

tion, dont l'expérience m'a permis d'apprécier toute la force, m'a déterminé à renoncer à plusieurs autres mesures que j'avais d'abord essayé de prendre, et à me contenter, en définitive, des six mesures que j'ai définies."

The six measurements to which Parchappe refers are the following: greatest length, greatest breadth, glabello-inion arc, bi-temporal arc from the top of one auditory meatus to the top of the other, arc through the superciliary ridges from the front of one auditory meatus to the front of the other, arc through the external occipital protuberance from the hinder border of one auditory meatus to the hinder border of the other. The results of all these measurements Parchappe added together; their sum represented for him an approximation of the volume of the head or the skull as the case might be. By this method Parchappe sought to show the influence of age, sex, stature, intelligence, race and climate upon skull. He then proceeded to discuss the comparative influence of these various factors. It is quite important to note that Parchappe was attempting to devise a method for the approximate estimate of cranial volume on the living. The discussion of the application of these results to the brain itself is also very thoughtful.

"Les diverses méthodes imaginées pour apprécier le volume du crâne ne consistant pas dans une mensuration exacte, ont été à bon droit, jugées impropres à atteindre le but pour le crâne lui-même. A plus forte raison doivent-elles être considérées comme insuffisantes pour faire arriver, par induction, à l'appréciation du volume de l'encéphale.

"Pour obtenir des faits scientifiques, il faudrait mesurer l'encéphale *lui-méme, ou tout au moins la cavité cranienne.* Je n'ai pas négligé ces deux modes de détermination du volume de l'encéphale; mais j'ai cru devoir leur préférer un procédé plus commode et plus sûr, la détermination du poids."

However Parchappe was not insensible to the difficulties incurred in weighing the brain. He discusses these sources of error while defending his chosen method.

To return to the six measurements, we find the following statements regarding relative volume in sex and race. The figures of course are the sum of the six measurements.

Head:	Male, White; mean of ninety	1630.6
	Female, White; mean of seventy	1551.2
Cranium:	Male, White; mean of twenty	1438.3
	Female, White; mean of ten	1354.2
Male Cranium:	White; mean of twenty	1438.3
	Mongolian; mean of nineteen	1418.7
	Negro; mean of nineteen	1420

Malay; mean of nineteen	1375.6
American; mean of nineteen	1391.7

Now it will be noticed that Parchappe's method must, by its very nature, give an inaccurate estimate of capacity, yet the author himself never claimed for it anything more than an approximation. It does not give even an approximately correct idea of the racial differences as we find them on our material but it is nevertheless wonderfully close as an early approximation of the true average volumes and of the relative volumes of males and females of White Stock. It is perhaps not so striking that later shots in the dark at a modulus by even less defensible, and at least equally unmathematical methods, have done little to better Parchappe's results when it is realized that in these very measurements, chosen with such great care, Parchappe had included so many significant factors in the make-up of that irregularly formed brain-box which we call the cranium.

In 1857 Gratiolet reviewed the observations of Lelut, Parchappe and Van der Hoeven upon measurements of the cranium. He had been roused by the work of Tiedemann to considerable indignation and being bound to admit the probable exactitude of the several measurements taken by the three men just mentioned, he feared that these might strengthen the position taken by Tiedemann's supporters. He therefore points out that the measurements were taken on the exterior of the cranium and that in view of the varying thickness of the cranial walls, one cannot infer with any degree of exactitude the cranial capacity from the volume of the cranium. "Que conclure de là, sinon que les dimensions extérieures du crâne sont des indices infidèles de la capacité intérieure?" (19). One might wonder why Gratiolet did not refer to the actual capacity until one realizes that in those days this measurement was recognized as very untrustworthy. "Peut-être pourra-t-on supposer qu'il est plus utile de mesurer la capacité du crâne; c'est là une opinion fort juste, mais les occasions de faire ce travail sur une vaste échelle m'ont manqué, et d'ailleurs, cette étude ne peut conduire qu'à des résultats peu certains." What Broca conceived to be the equivocal attitude of Gratiolet brought down upon the latter Broca's oratorical ire in the controversy soon to follow.

Broca knew very well the investigations of Parchappe and he made use of them in the famous controversy of 1861 in the Paris Anthropological Society (9). He recognized the great importance of Parchappe's work but he insistently and properly pointed out its weak place, namely the error in which one must fall when one takes a very approximate measurement and then tries to draw conclusions based upon relatively

small differences. Further the types of measurement are diverse and the cranium, by its irregularity of form, eludes all geometrical evaluation. Finally, after a typically clear and logical analysis of the interpretations drawn, or held to be drawn, by Soemmering, Parchappe, Van der Hoeven and Gratiolet, Broca concludes that, "le procédé de M. Parchappe est certainement le plus vicieux de tous." Of course we must remember that Broca was arguing upon the influence of intelligence which Parchappe found to be slight, and further was imbued with a conviction that the White man stands out in his intelligence from other races, especially the Negro for whom Tiedemann had put forward so effective an appeal.

It is certainly striking that four years after his denunciation of Parchappe's method, Broca himself should defend a mathematical estimate of cranial capacity based upon the diameters. True, Broca did not use this method for skulls of which the capacity could be determined directly. It was the desire to demonstrate the unusually large size of Schiller's head, denied by Gratiolet but needed by Broca in his defence of the relation of intelligence to cranial capacity, which drove Broca to utilize the approximation by computation. Broca at first merely multiplied together the greatest length, greatest breadth and basiobregmatic height and, finding the product somewhat more than twice the actual capacity of the skull in question, divided this product by two. Stimulated by the unexpected approximation, though recognizing the difficulties entailed by a non-geometric body and by the varying thickness of the bones, Broca investigated the question still further and found *that the relation of the quotient obtained as just indicated to the actual* capacity varied only within narrow limits. In fact the quotient lies between 1.040 and 1.205 times the capacity as determined by the direct method. Dividing the quotient therefore by 1.205 the minimum capacity is obtained; and dividing by 1.040 the maximum capacity is found (12). This divisor of the quotient ultimately fixed at 1.902 Broca called his cubic index.

In 1880 Manouvrier (31) adapted the index anew, allowing for the error in Broca's original crâne étalon, separated sex and race, and also suggested that cephalic index would have some influence.

In 1901 Pelletier (40) at Papillault's suggestion worked out Broca's index again in relation to metopic diameter, greatest transverse diameter and auricular height, making necessary corrections for sex and cephalic index.

All these methods, being no more than guesses devoid of any mathe-

matical principle, fall under the stigma which Broca himself applied to the method of Parchappe.

At the time when Broca was working at cranial capacity Hermann Welcker was thinking of the possibility of using the sum of the cranial diameters as an expression of volume (63, p. 98). Like Broca he determined on the glabellar length, the greatest breadth and the basio-bregmatic height. The sum of these he called his Schädelmodulus. Welcker's first idea was that the sum of the three diameters might be used as a brief summary of the characters of any cranium. He proposed to use as his standard the sum of diameters of the German skull and reduce the corresponding figure for the skulls of other races to a percentage of the standard (63). It was not unnatural therefore that he should later employ his modulus as a basis for the calculation of cranial capacity. In 1886 Welcher finally published his method with tables from which the capacity could be read once the diameters and the cephalic index were known (64).

In 1880 Schmidt had proposed to alter Welcker's modulus by dividing the sum of the diameters by three (48). This Welcker vigorously opposed (64). But in his search for a modulus which should be more dependable than Welcker's as an accurate expression of capacity, Schmidt obtained the capacity of skulls rendered water-tight by submerging them upside down to the level of the Frankfort plane in a special apparatus and then worked upon a figure obtained from the cube root of the products of length, breadth and height (48).

None of these methods, either French or German, has come into general use for none carries conviction. It is claimed that although Manouvrier's method may give an error in individual skulls of 100 cc., yet on an average in small series the error is not more than 25 cc. Welcker's method is supposed to give an average upon ten skulls not more than 10 cc. wide of the mark. Nevertheless the methods are not in accordance with mathematical principles and are now obsolete. Froriep indeed attempted to revive Broca's method under a new guise in 1911, allowing for the thickness of the skull bones but he has ignored entirely the most important work on this subject, namely that done in Pearson's laboratory.

Naturally cranial circumference has not been omitted from consideration in the computation of capacity although such a method must be less dependable than one involving diameters since the influence of height is necessarily entirely left out of consideration. Boas imagined that on the living a method based upon circumference would be the

most practical (7). Welcker (64) developed a modulus depending upon circumference in 1886 and since then several investigators have applied themselves to this method. In 1885 Rieger published a scheme of cephalograms the object of which was to reproduce the main features of the skull. From the cephalograms with the aid of a constant he estimated capacity. Most of the work of this nature has appeared from Rieger's Clinic, (e.g. Beck, 1907 (2), Röll 1910, (45), and Dessloch 1912 (15). Beddoe in England gave great attention to estimation of capacity from circumferential measurements (3), but as in the case of all other efforts so far mentioned there was no attempt to develop the method upon a correct mathematical basis. We need not discuss his scheme in detail: it has already been shown by Lewenz and Pearson that such speculations are idle. (29).

PEARSON'S METHOD FOR CORRELATION OF THE HUMAN SKULL

We are now in a position to review the determination of cranial capacity by direct methods. A careful study of all the writings discussed has made it quite clear that direct estimates may give a fairly close approximation to the average if the series be even moderate speaking in terms of anthropological series. Macdonell's observations give us confidence in this expectation. We may assume a probable error of not more than 20 cc. on any reasonable series of carefully determined capacities by any well controlled direct method since Macdonell found no more than this on very short series, the results being checked by different observers and different methods. It is true that Macdonell is more optimistic than this for long series. I think he is justified in expecting a difference in such series of not more than 10 to 15 cc. even by different methods. So far as individual skulls are concerned the reliability will be less. In spite of Miss Fawcett's hopefulness I cannot accept a probable accuracy to within less than 40 cc. in a method utilizing vegetable seeds and in occasional instances the error may be still greater. Notwithstanding these drawbacks direct determination is still the best method provided the material permits of it and there is time to carry the technique with all necessary care. The fact is however that many skulls do not permit direct cubage and these skulls are usually the most valuable. Hence there is every encouragement to develop an indirect method of computation. To carry any weight this computation must be made upon a sound mathematical basis. Such a basis is not provided in any of the methods so far discussed. By sheer accident, it is true, any one of the methods may give an unexpectedly close approxi-

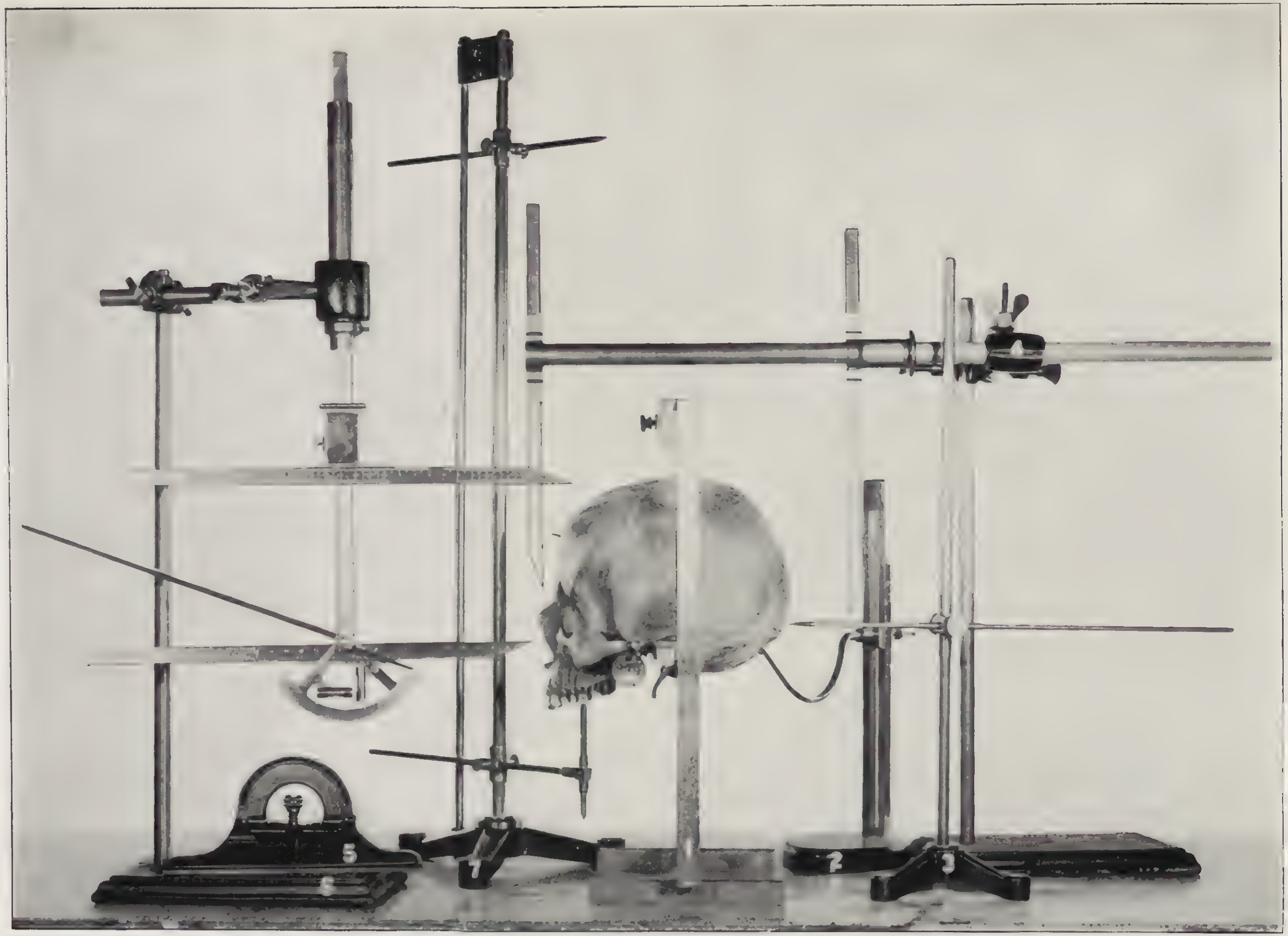

FIG. 1 Apparatus used in measuring lengths and auricular heights of skulls oriented in Frankfort plane, called in this work the "Old Apparatus."
1. Reserve head-frame; 2. Diagraph used to support occiput; 3. Horizontal needle; 4. Stangenzirkel held in jaws of osteophore and used to determine greatest length; 5. Spirit level; 6. Stativgoniometer used for measuring auricular height; 7. Parallelograph as employed to support palate.

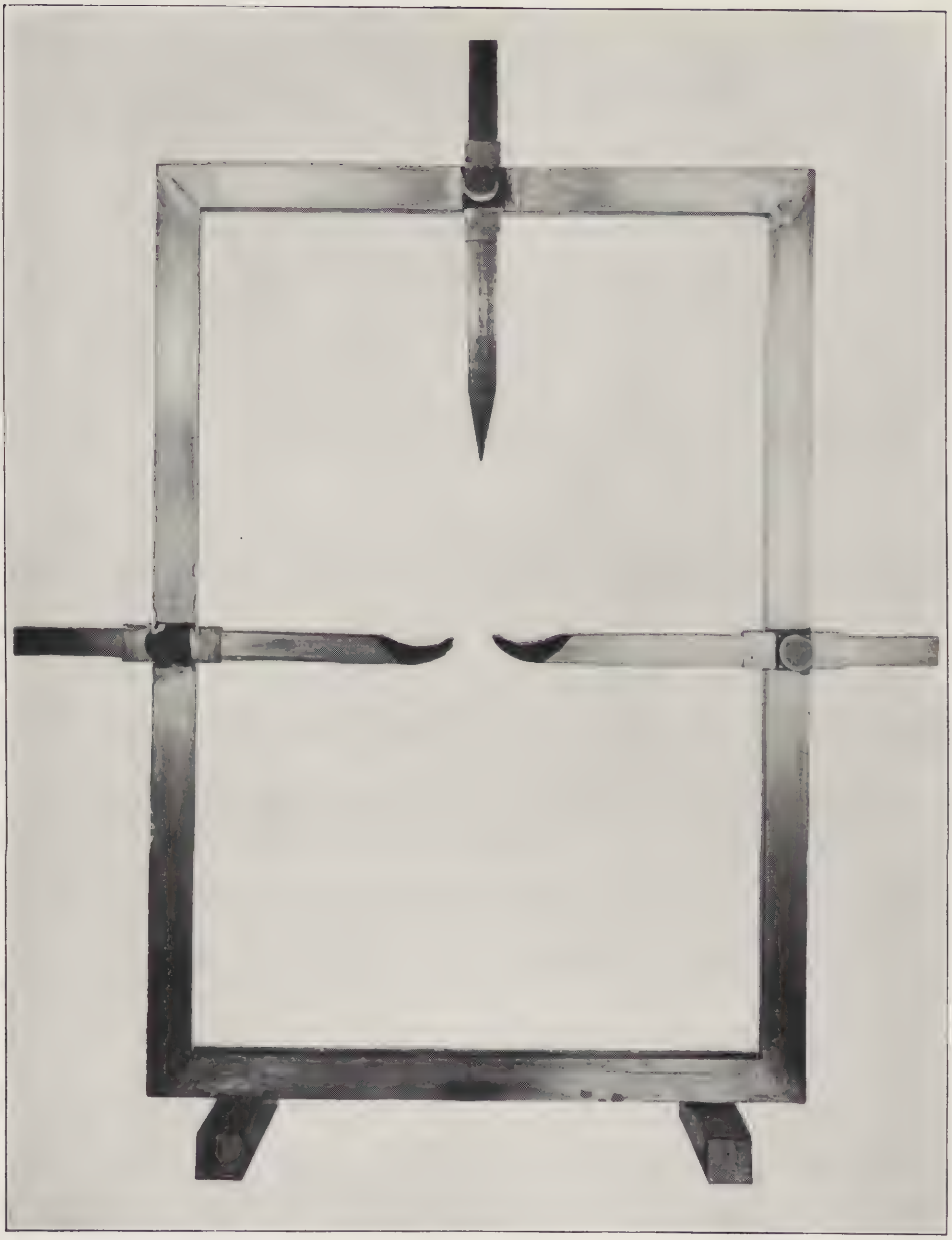

FIG. 2. Reserve head frame as seen from the front.

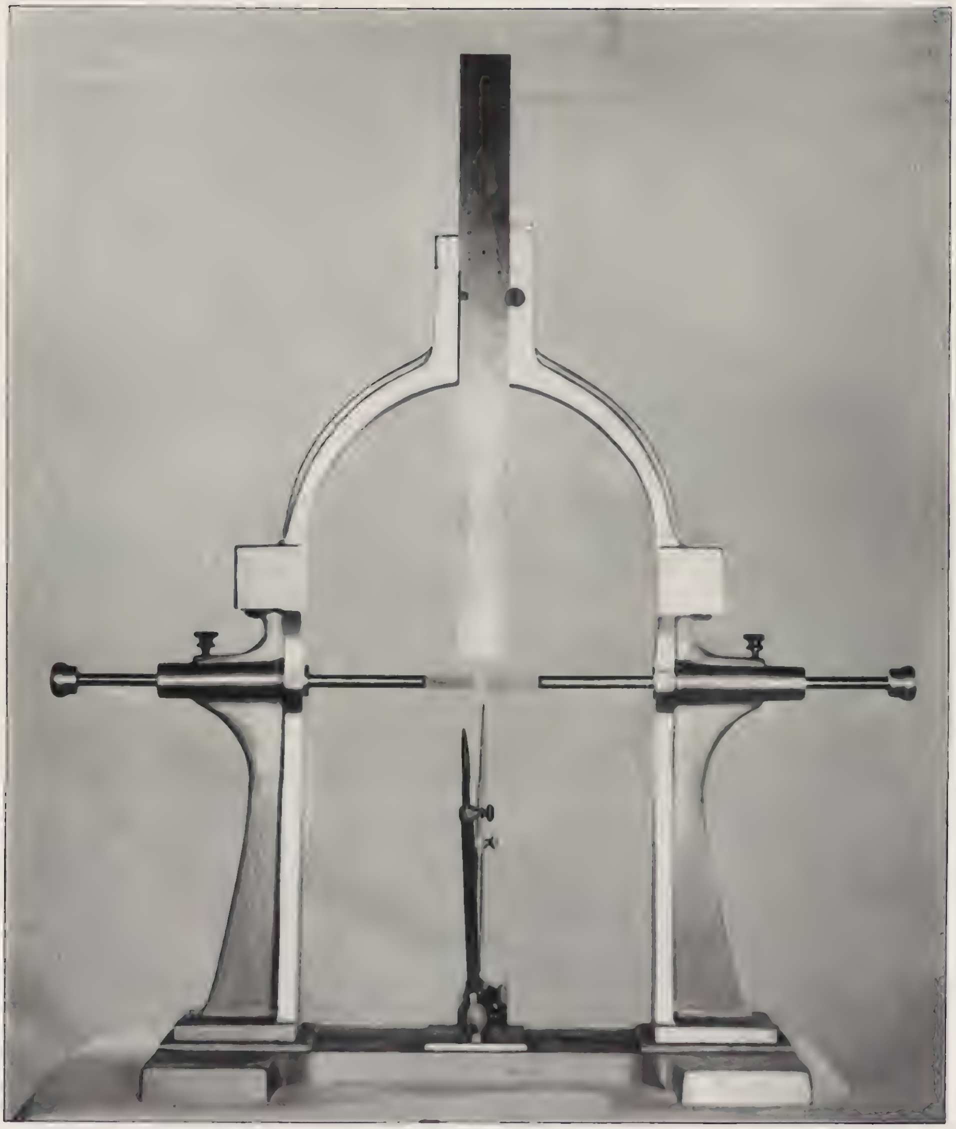

Fig. 3. The Reserve Craniostat as seen from the front.

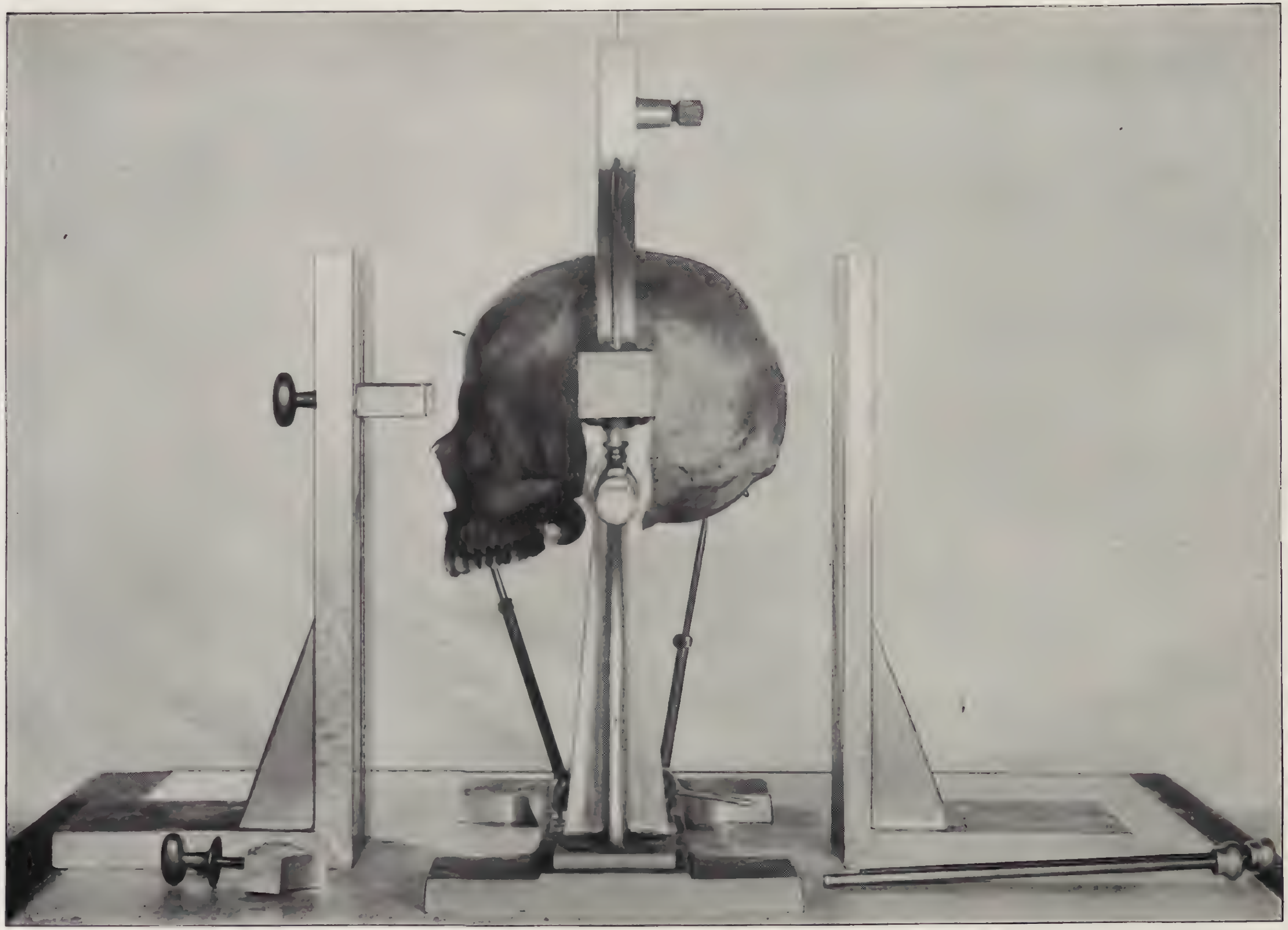

Fig. 4. Reserve Craniostat and Cambridge Blocks mounted upon millimeter paper. By the former the auricular height is determined. The Blocks give greatest length. In this illustration the front block has mounted upon it the flat aluminium projection for determining greatest length including superciliary ridges (see Fawcett16). This assemblage of instruments is defined in the text as the "New Apparatus."

mation to cranial capacity found by direct cubage. Both are approximations and they may give either harmonious or disharmonious results in any particular instance. But at best the method cannot convince the careful observer who knows that by its defects indirect cubage is often no better than a fortunate guess and, like all speculations, very liable to fail on important occasions.

The great service which Pearson has done for cranial capacity computations is to develop a method strictly in accordance with mathematical theory, a method moreover which can be tested and of which the technique is readily understood. Indeed it is somewhat surprising that a method bound by circumstances to be immensely valuable has not received greater attention from Anatomists and Anthropologists, and has not been assiduously tested and extended. Perhaps this is due to the difficulty of obtaining series of measurements large enough to make such scrutiny possible. The workers in the Biometric Laboratory have endeavored to extend the method whenever series sufficiently homogeneous to render this possible have presented themselves (e.g. 28, 25) but I find no genuine effort to apply the method on the part of other workers except Wacker (59) and no attempt at all to develop the method to a greater usefulness.

Let us consider for a moment the fundamentals which must be fulfilled by such a method if it is to be of real use in Anthropology. As has long been recognized the method must be applicable to the skull whethe dried or fresh, and to the head in the living. Its results therefore be sufficiently reliable to obviate the necessity of checking by cubage. The auricular height must be used in place of the basio-bregmatic. Greatest length and greatest breadth must be measured by a strictly defined method rigidly adhered to. These three measurements constitute the minimum number upon which any reasonably dependable formula can be built. Even then the method tacitly assumes the fundamental similarity in conformation and capacity of the basal part of the brain case, an assumption not warranted according to Pearson and Benington (6 p, 334). Concerning this feature we shall have something to say in a later communication. Circumference alone, as it ignores the height, cannot be expected to give good results. Indeed all arc measurements, if applied to the head itself, are not comparable or reliable as anyone would testify who has tried to carry them out on one of our typical negro women. When the formula is determined too much must not be expected of it. We are dealing with a non-geometric body with walls of uncertain thickness and, it may be, somewhat obscured by overlying soft tissues. The

tedium and the error of the direct method drive us to consider mathematical computation. We shall therefore ask no greater accuracy than the direct method gives and we shall be satisfied with something, though not much less. These conditions Pearson's method undoubtedly fulfills. Much of the present paper is devoted to a confirmation of the method; the remainder barely forecasts its still greater usefulness. We have already seen that so far as direct measurement is concerned we are still where Broca left us; no real addition to our knowledge or accuracy has been made since Broca ceased his labors. As regards determination by computation Parchappe saw clearly enough what was required but he did not know how to attain the results he desired and formulated. Pearson's work is the only real advance along this line of investigation and it is indeed a very great advance.

No satisfactory short summary can be given of the method which we are about to examine. The reader must carefully master the original work in all its details. He is referred therefore to the monograph by Lee and Pearson (28) and to the second paper by Isserlis (25) which extends the method to the Negro skull.

THE METHOD OF TAKING LINEAR DIMENSIONS OF THE CRANIUM

In order to investigate the possibilities in mathematical computation of cranial capacity by Pearson's method we had to devise an equipment of instruments by the use of which the measurements taken would be as closely comparable as possible with those upon which Lee and Pearson based their formulae. The greatest breadth measurement entailed no difficulty; it has throughout been taken with a Flower's craniometer. For greatest length and auricular height it is necessary to adjust the skull to the Frankfort plane and we do not possess a Ranke's craniophor. We do possess however most of the instruments made by Hermann under Martin's direction, and in order to obtain the two dimensions mentioned we have assembled the instruments illustrated in Fig. 1. The skull is suspended in the Reserve head frame (Fig. 2), the points of the arms each resting on the roof of the external auditory canal immediately within the orifice (1. Fig. 1). With the aid of the diagraph (2) and the parallelograph (7) as skull supports and the horizontal needle (3) to adjust the level of the lowest part of the orbital margin, the skull is oriented in the Frankfort plane. The greatest length is then taken by means of the stangenzirkel held in the jaws of the osteophore (4), and the auricular height is measured on the stativgoniometer held in the

other osteophore (6), The spirit level (5) enables one to be sure that the stem of the stangenzirkel and the fixed limb of the stativgoniometer are precisely horizontal for each determination. All the instruments are mounted upon the marble plate to ensure uniformity in the basal plane. This group of instruments we shall define in later pages as the old apparatus since it has proved possible and necessary to manufacture new instruments by which we have checked the accuracy of the "old."

The technical details of taking the measurements are quite important and must receive attention if the results are to be compared with those by other methods. In each case the greatest breadth is determined by the lightest pressure of the jaws of Flower's craniometer and the site of greatest breadth recorded according to Martin's scheme (32, p. 522). In adjusting the points of the arms on the head frame it is found that the roof of the external canal presents a varying relation to the upper margin of the external orifice; sometimes the roof lies well above this level, sometimes below. The horizontal needle is not adjusted to the tip of the arm point but to the point where the roof of the canal and the margin of the external foramen meet. It is quite necessary to realize this for one finds that the slight differences of adjustment of the skull necessitated by changing from the old apparatus to the "new" results in a possible divergence of one or even two millimeters in auricular height. The skull being firmly oriented in the Frankfort plane, length and height are determined. Many skulls are asymmetrical and a measurement along the median sagittal diameter would not give the greatest length as demanded by the Frankfort agreement. This difficulty is surmounted in our measurement very simply. The horizontal position of the stem of the stangenzirkel is verified by the spirit level. The fixed arm is then adjusted to the glabella. Being narrow the arm is not debarred from touching the glabella by large superciliary ridges. The movable arm has been so modified that it permits some swinging upon the horizontal axis of the stem without modifying the accuracy of measurement. Hence by the swinging motion this arm is so adjusted that it exactly clears the most backwardly projecting part of the occiput. In order to determine auricular height the fixed limb of the stativgoniometer is adjusted exactly to the point used as a standard for the horizontal needle. The other limb, projecting further from the stem, is then depressed until it just clears the upper part of the cranium vertically below the device on the upper bar of the head frame which indicates the crossing of the median sagittal plane and the bi-auricular plane as identified by points of the arms. Of these measurements the last is the

least satisfactory; it is difficult to measure since so many adjustments have to be made upon both skull and instruments. It was for this reason that I asked Mr. Cherny to devise and manufacture an new instrument which I shall describe later. As all the measurements upon auricular height for this memoir were made with the "old" apparatus, the technique has been fully described although in future it will be discarded in favor of a more direct method shortly to be presented.

Since the so-called "new" apparatus enters into the experiments for determination of accuracy it will be of advantage to describe it at this point. The head frame devised for the work of Dr. J. A. Toomey upon the mid-line of the skull, not yet published, was rather cumbersome for the determination of auricular height. When Mr. Cherney joined our staff I asked him to undertake the manufacture of various instruments among them a craniostat upon similar lines to those of Ranke's craniophor. The final form of this instrument is shown in Fig. 3. By it the auricular height is measured directly. The skull is supported upon the arms which fit into the external auditory canals, and is oriented in the Frankfort plane with the aid of the horizontal needle, the skull being retained in position by means of the adjustable limbs which take the place of Ranke's device. The zero mark on the scale is at the exact level of the reading ledge when the scale is depressed to the level of the arms. Hence the reading on the scale when its foot touches the vertex of the skull gives directly the auricular height. But it must be noted that this auricular height is not precisely the same as the measurement given by the stativgoniometer. In the latter case auricular height is the distance of the vertex of the skull oriented in the Frankfort plane, vertically above the plane passing through the points where the roof of each external auditory canal joins the margin of the external auditory meatus. With the new craniostat we measure the height of the vertex above the plane passing through the lowest points of the roofs of the external auditory canals. The two measurements may be the same or they may differ by as much as two millimeters. This is not merely an instrumental error; the auricular height as determined by the two instruments is not exactly the same measurement. I infer that the new method more closely approaches in its result the method employed by Ranke.

With the skull mounted in the craniostat it is quite simple to obtain the greatest length. Fig 4, shows the details of the technique. The block-squares were made after the pattern employed in Professor Pearson's laboratory except that Mr. Cherney has cast these in aluminum, so avoiding any possible warping. Since these instruments were made

for Pearson by the Cambridge Scientific Instrument Co. we usually term them the Cambridge Blocks. The craniostat with the skull and the blocks are set up on a drawing board on which is glued a sheet of ruled millimeter paper carefully checked over to insure accuracy of measurement. This base has been coated with the celluloid varnish already described to enhance its durability. The auricular axis is arranged parallel with the ruling. The back block is adjusted to the occiput. The front block has a small projecting piece which enables it to be fitted to the superciliary ridges or the glabella if that be the most forwardly projecting part. The extreme length of the skull is then read from the millimeter paper. This method was employed to permit us to compare our measurements with those of Miss Fawcett (16). For usual occasions the small adjustable projecting piece on the front block is replaced by a wedge-shaped piece fitting in all cases to the glabella.

In all measurements our reading is correct to the nearest half millimeter. One can indeed determine the auricular height upon our own craniostat to 0.25 mm. but this nicety is not possible with the other instruments. The estimate of reliability of the several measurements is most important and a statement of the experimental observations upon accuracy follows in due course.

It may be well to state that the auricular height has been used primarily because that was the height chosen by Pearson. But also this measurement is undoubtedly the most serviceable because it is the best height determination possible on the living. The problem of racial difference in that portion of the basio-bregmatic height below the plane of the external auditory meati discussed by Pearson (6, pp 302-3) will receive attention on a future occasion. Another reason for employing the auricular height is its closer relation to the most variable part of the cranium, namely the cerebral fossa. The main idea which I have had constantly in mind is not the substitution of new methods even though more accurate and reliable, but rather comparison of the measurements already made by others, but now with reference to a large and well authenticated material which may become a standard material for further investigations.

EFFECT OF OUR ROUTINE TREATMENT OF THE SKULL

In most museums the skulls are intact except in the case of those already broken upon arrival. These do not permit so close a study as the bisected skulls which are the rule in the Hamann Museum. There is almost everywhere a prejudice against bisecting a skull in spite of

Huxley's well placed criticism. After all this is not unnatural for bisection of a dry skull is well nigh impossible without some damage to turbinals or palate at least. With our material it is different. There is no need to damage these structures in the natural skull and indeed we have learned to manipulate the saw so that even deflected septa are retained intact. The question of course is what effect our method may have upon the skull in drying. It is well known that exhumed skulls show great post-mortem deformation and that these skulls in drying warp still more. It is also certain that the usual long protracted method of macerating skulls employed in most laboratories and the boiling to which many anatomical preparators subject their material have a pronounced effect in softening the skull which is then deformed by slight pressure and warped in drying. Yet I hold that no skull is really serviceable until it has been bisected and it would be quite impossible to secure the brain, a very important part of our systematic work, unless the skulls is bisected.

For the reasons just stated Mr. Leonhart made an exhaustive and very careful investigation into all possible methods of macerating and has finally evolved a technique which deserves record in another communication but of which the principle is maceration by live steam. During the past eight years this is the technique employed at Reserve for all human skeletons over sixteen years of age. A fresh cadaver is macerated by this method in twenty-four hours, a formalin hardened cadaver in two to three days. By a system of cleaning with electrically driven bristle (not wire) brushes the entire skeleton lies finished upon the drying table three hours after it has been taken from the macerator. After drying at room temperature for from three days to a week according as to whether there is or is not steam heat in the building all individual bones are inscribed with the cadaver number which is then varnished with celluloid to prevent its being rubbed off and the skeleton in its box is passed on to the anthropological room for examination and description.

By this rapid method we are able to cope with the large number of skeletons accruing yearly to the collection. It also ensures that no skeleton remains in maceration long enough to permit the bones to become softened. Thus we have no trouble from bones warping during drying. The familiar separation between parietal and squamous temporal so apparent in exhumed material is never seen here. The two halves of the skull fit together perfectly and show no sign of distortion. After the halves are pinned together the skull is as good as if intact for all purposes

except the trigonometric investigation of the base. We have devised ways of overcoming this disability. The readiness with which the skull can be opened for observation of the interior far out-weighs this theoretical objection.

The cautious reader must not imagine that bisection of the natural skull interferes in any real degree with its later usefulness.

ACCURACY OF THE LINEAR MEASUREMENTS ON THE DRIED SKULL

There are really two problems united under the heading of this section, namely, in the first place, how nearly measurements can be repeated with the same instruments and secondly, how closely the same measurements may coincide when taken by different instruments. In order to have some guide to the instrumental error, which must of course be discounted in the rather difficult estimation of shrinkage of skulls in drying, I took ten well dried male White skulls split in the median sagittal plane and made anew observations of length, breadth and auricular height, using first the old apparatus and second the new. These results I used to check my original figures in the observations already made and forming part of the series upon which my correlations have been computed. All three series are given in Table VII.

TABLE VII.—COMPARING THE RESULTS OF REPEATED MEASUREMENTS WITH THE SAME INSTRUMENTS AND WITH DIFFERENT INSTRUMENTS

Measurements upon the bisected skull.

Skull	Length			Breadth			Auricular height		
	A.	B.	C.	A.	B.	C.	A.	B.	C.
610	179.5	180	180	147	147	147	122	122	121
614	188	188	188	148	148.5	148.5	116.5	116.5	115.5
617	178	178	178	139	139	139	109	109.5	110.5
618	159	159.5	159.5	147	146.5	147	109.5	108	108
619	178.5	179	178.5	147	147.5	146.5	117	116.5	117
622	173	173	173	149	148.5	148	118.5	117	117
623	194.5	195	195	146	145	145	121	120.5	121
626	177	176.5	177.5	139	139	139	120.5	119	119
627	188.5	188.5	188	145.5	145.5	146	120	117.5	119.5
628	173.5	174	174.5	145	145	145	112.5	111	112
Total deviation from col. A.	3.0		3.5		3.0	3.5		10.0	8.0
Total deviation of col. C. from col. B.			2.5			2.5			7.0

Columns A. and B. for length and height consist of observations made with the Reserve head-frame, stangenzirkel and stativgoniometer (Fig. 1.). Column C. for length and height gives the observations made with the Reserve craniostat and the Cambridge blocks (Fig. 4). All the observations on breadth in columns A, B and C were made with Flower's craniometer.

In this table the measurements of breadth can be considered separately from those of length and height since all breadth measurements were taken by Flower's craniometer. The maximum breadth was found invariably to occur in the same location each time the measurement was made: the precise site of greatest breadth however will be taken up in a later communication when comparison with the same measurements on the fresh cadaver are discussed. At the moment we note that the average discrepancy of measurement varies between 0.25 and 0.35 mm. Greater accuracy than this must not be expected. The actual individual deviation is not more than 0.5 mm. except in No. 619 where there is a discrepancy of 1.0 mm.

The observations on length and height fall into a different category for we compare the influence of different instruments upon these measurements. So far as length is concerned there is an average divergence of 0.3 mm. on the old apparatus (Fig. 1) and comparing measurements taken upon the old and the new (Fig. 4) apparatus we find an average divergence of 0.25 – 0.35 mm. In no case is the individual difference greater than 0.5 mm.

Observations upon auricular height are not so constant in result. The average divergence on the old apparatus is 1.0 mm. and the greatest individual difference may be 1.5 mm. and in one case, No. 627, 2.5 mm. Comparing the old with the new apparatus we find an average deviation of 0.7 – 0.8 mm. with a greatest individual divergence of 1.5 mm.

Taking the entire series of twenty measurements on length and height we find the following results:

	Old apparatus	New apparatus
Identical results	6	6
Difference of 0.5 mm.	9	7
Difference of 1.0 mm.	0	5
Difference of 1.5 mm. (or over)	5	2

From these results and those obtained on breadth by Flower's craniometer it is plain that there is very little difference in constancy between observations repeated with the same instruments and observations taken with different instruments. The really important factor is care in making and reading the measurements. Auricular height is less dependable than length or breadth. This is in part due, as has been indicated, to the difficulty of measurement caused through variations in precise conformation of the external auditory meatus and canal, but also to a certain clumsiness in the head frame. The craniostat is a much more reliable instrument for this measurement, for in a further series of observations we shall see that the average divergence in repeated measurements of

height by this instrument is only 0.2 mm. instead of the maximum average of 1.0 mm. on the head frame. Hence the craniostat will be used on all future final measurements for correlation.

When we come to determine shrinkage in linear measurements due to drying of skulls it will be necessary to deduct the instrumental error in order to obtain as nearly as possible an accurate idea of the minimum effect of drying. With the old apparatus we have seen that the average maximum instrumental error is L. 0.30 mm., B. 0.30 mm., H. 1.0 mm.

PRACTICAL EFFECT OF THE SAW-CUT UPON LINEAR DIMENSIONS OF THE SKULL

In computing the instrumental error we have used measurements only upon the dried bisected skull. But if, as we eventually shall, we desire to apply our information towards the estimation of shrinkage resulting from drying, it will be necessary to know the precise effect upon breadth which results from bisecting the skull. Any skull would serve but I have chosen No. 883 as an example. After cutting but before macerating this specimen I carefully measured the breadth of the saw-cut and found it to be 1.5 mm., the saw itself having a thickness of 1.0 mm. The extra half millimeter is of course due to the spread of the teeth. It is not difficult to measure the breadth of the saw-cut accurately for in most skulls there are one or two places where the saw has not completely severed the bone which has finally been broken by the prying apart of the two halves with a chisel. Indeed we prefer to complete the cut in this manner for thereby the real breadth of the skull remains undiminished by the bisection. How fully this expectation is realized I have attempted to show in Table VIII. The average breadth of these twenty skulls was scarcely diminished by the procedure; on the contrary the breadth was actually increased in some. This result compares well with the instrumental error as already shown.

Perhaps naturally one may object that the saw-cut in the fresh skull may bring about just this result by permitting small fragments of dura to insert themselves in the crevice between the two halves. If this were so the result would surely average more than an instrumental error. The small increase in some might be an illusion due to the actual reduction in breadth being somewhat more than compensated by thickness of the intervening dura. To answer this objection it would be necessary to repeat the observations upon the dried skull before and after bisection. It should be stated that this work was undertaken at the very beginning of these researches with the result that no actual appreciable diminution

was found. The records of this work unfortunately disappeared during the interruption of the investigation by the war and have never since been discovered. At this time in consequence of our technique we have no skulls upon which the work could be repeated. It will be fairly apparent however, in consequence of the preservation of bone ledges, that no appreciable contraction of breadth need be expected.

TABLE VIII.—SHOWING THE INSTRUMENTAL ERROR ON THE NATURAL SKULL AND THE EFFECT OF THE SAW CUT IN THE MEDIAN SAGITTAL PLANE

(OLD APPARATUS, FIG. I.)

Skull	Length before Cutting	Length after Cutting	Breadth before Cutting	Breadth after Cutting	Aur. Height before Cutting	Aur. Height after Cutting
724	180.5	181.5	134.5	135	113.5	112.5
751	180	179	132.5	132.5	114	114.5
773	185.5	184	141	141	113	113
864	191.5	191	147	147	118	117.5
874	186	184.5	145	146	119	117
875	189	189	149	148	122	122
876	178	177.5	137	137.5	115	116
883	190	190	144	144.5	118.5	117
886	184.5	184	133.5	134.5	119	119
887	185	184	153	154	116	116
888	187	186.5	136	137	118.5	120
889	184	185	151.5	151	123	123
890	190	190	152	152	110.5	108
891	195	195.5	146	146	112	112
892	188	186.5	139.5	138.5	118	118
893	163.5	163.5	127	127	109	108.5
895	195	196	142.5	143	125	126.5
896	203.5	204.5	136	135.5	112	114
897	188.5	188.5	141	142.5	114.5	115.5
898	188	187.5	153	154.5	114	116
Average	186.625	186.4	142.5	142.35	116.225	116.3
Deviation by sign on 2nd estimation		+4.5 —9		+9.5 —2.5		+9.5 —8
Total deviation		13.5		12		17.5
Average deviation		0.675		0.60		0.875

At the same time one should note the general effect of bisection upon other measurements as shown in the table. Concerning length it is noted that bisection results in a deviation scarcely more than twice the ascertained instrumental error, namely, an average of 0.675 mm. So far as auricular height is concerned the average deviation of 0.875 mm. is still within the instrumental error of the method. The length deviation confirms our belief that there is nothing significant in any possible difference brought about in breadth.

ACCURACY OF LINEAR MEASUREMENTS WITH THE NEW APPARATUS

We have noted the reliability of measurements made with the assemblage of instruments known as the old apparatus and have compared these results with those obtained with the new. In order to avoid any uncertainty on this important matter I have taken another series of ten skulls, all bisected and museum dried, and made two sets of observations upon length, breadth and auricular height, using Flower's craniometer and the new apparatus. The second set of measurements was made two days after the first. By this scheme I have a check upon the previous series and am able to ascertain the relative reliability of the old and new apparatus.

TABLE IX.—COMPARING THE RESULTS OF REPEATED MEASUREMENTS WITH THE RESERVE CRANIOSTAT, CAMBRIDGE BLOCKS AND FLOWER'S CRANIOMETER

Measurements on the bisected skull.								
	Length				Breadth		Auricular Height	
Skull	A.	B.	C.	D.	A.	B.	A.	B.
752	180	180	180	179.5	154.5	154	116.5	117
848	186.5	187	184.5	185	143.5	144	113	113.5
856	173	173	171.5	171.5	135.5	136	115.5	116
865	186	186.5	186.5	186.5	143	143	112	112
867	175	175	174.5	173.5	139.5	140	112.5	112.5
875	187.5	187.5	187	187	146.5	146.5	121.5	121.5
876	176.5	176	176	176.5	135	135	113	113
878	180	180	179	179	148	148	118.5	119
882	168	168	.169	168.5	151	151	117	117
885	171	170	170	168	141.5	142	111	111
Total deviation from column A		2.0				2.5		2.0
Total deviation from Column C				5.0				
Total maximum deviation of column C or D A or B			11.5					

Figures in columns A and B for length and height are observations made with Reserve craniostat and Cambridge blocks. Figures in columns C. and D are measurements taken with Flower's craniometer.

Figures for breadth are observations made with Flower's craniometer.

The results of this inquiry are given in Table IX. Columns A and B for length show an average difference of 0.2 mm. with the Cambridge blocks, and a maximum individual divergence of 0 5 mm. This, upon the average but not individually, is a slight improvement in constancy upon the stangenzirkel. So far as breadth is concerned the average difference of 0.25 mm. merely confirms the better of the two comparisons for Flower's craniometer given in Table VII. So far as auricular height

is concerned there is a distinct improvement over the results obtained by the head-frame and the stativgonimeter. In that case we noted an average divergence of 1.0 mm. and an individual difference once of 2.5 mm. With the craniostat there is no single instance of more than 0.5 mm. difference and the average is only 0.2 mm. It is plain then that for the future all measurements of auricular height will be made upon the craniostat.

Summing up we find the average error for breadth of about 0.3 mm. for Flower's craniometer confirmed; the average error for length of about 0.3 mm. with the stangenzirkel slightly reduced, and the average error of height of 1.0 mm. with the head-frame and goniometer reduced to 0.2 mm. In the case of length the Cambridge blocks give a scarcely more accurate result but their use is much less wearisome.

Now the much greater constancy of result attained for auricular height with the craniostat may raise the suggestion that perhaps our observations with the head-frame are invalidated, and should be discarded in spite of the fact that so much work has been done with this instrument. I do not share this impression although at first I did defer decision until I had given the matter careful attention. In Table VII the totals of all the measurements of auricular height for columns A, B, and C are respectively 1166.5, 1157.5 and 1160.5 mm. Hence column C which was obtained with the craniostat falls within the limits of the two columns obtained with the head-frame and goniometer. The instrumental error of the craniostat is such that the total of this column cannot be far wrong. As it stands the total of column C is within 1.5 mm. of the average of the other two. Allowing for the slight difference between the actual distances measured by the two sets of instruments the probable error of the mean over a large series is not likely to vary whichever set of instruments be used. For this reason the series of determinations with the old apparatus is permitted to stand.

THE USE OF FLOWER'S CRANIOMETER FOR MEASUREMENT OF LENGTH

We have discussed various phases of the instrumental error but there remains one other error which may have a considerable influence upon the result of determination of the cranial capacity from measurements in the living, namely the use of Flower's craniometer for establishing greatest length. Obviously this instrument or another upon similar principles is the most suitable for determining length in the living. I do not propose to take up at this stage the relation of measurements upon the head of the fresh cadaver to the same measurements upon the

skulls of the same cadaver but it is necessary to emphasize the fact that greatest length as determined with Flower's craniometer is not quite the same thing the greatest length which we are discussing. This instrument measures the distance between points not areas and therefore there is bound to be a difference in length of an asymmetrical skull according to the instrument used. We have seen that this difference does not apply to our modification of the stangenzirkel. What may be the case in comparing the living measurements with those taken on the skull of the same individual I do not know: it is not possible in the cadaver to orient accurately the visual axis in the horizontal plane. Therefore greatest length as determined by Flower's craniometer has no necessary relation to the Frankfort plane. It is then of importance to compare greatest length as measured in the first instance by the Cambridge blocks upon the skull in the Frankfort plane and secondly by Flower's craniometer without reference to this plane.

Table IX shows that the difference in individual skull length measured by the two methods just indicated is not inconsiderable. The average instrumental error itself is 0.5 mm. but the maximum average difference as elicited by the two methods in 1.15 mm. and the maximum individual difference is as much as 3.0 mm. In the next section it will be seen that this difference is further intensified by the shrinkage which the skull undergoes in drying. We must then exercise great caution in applying the data obtained from skulls carefully measured in the Frankfort plane to the fresh head.

THE INFLUENCE OF DRYING UPON THE LINEAR DIMENSIONS OF THE CRANIUM

Earlier in this discussion I have shown that the diminution of cranial capacity consequent upon drying of the skull amounts to an average of of 58 cc. in a small series and I hazard the opinion that about 50 cc. should be allowed in general for this. I have also shown that, since the volume of the dura approximates this value, comparison may rightly be made between data upon capacity derived from the fresh cranium with dura intact on the one hand and from the dried cranium minus the dura on the other. I have also pointed out that whatever change occurs in the dimensions of the skull in drying takes place wonderfully uniformly since in the bisected skull the two halves fit perfectly whether wet or dry and at all stages in between. Now this question of possible shrinkage is bound to come up on many occasions and especially when we attempt to apply our information upon the dry skull to determination of capacity

in the living, so it is necessary to investigate the matter rather carefully. Inasmuch as we know fairly accurately the average error of our various instrumental methods we may discuss the question of shrinkage with some assurance.

In his study of alteration in capacity of the cranium consequent upon changes in humidity, Broca refers to Welcker's work with a courtesy and confidence which were scarcely returned in kind by the latter investigator (14). Broca had found an alteration of some 43 cc. as a result of soaking the skull and could not help a certain uneasiness concerning Welcker's denial of any appreciable change in linear dimensions, the more so since Welcker affirmed that if a fresh skull were bisected and then macerated the two halves no longer exactly correspond (14, p.65). There is no doubt whatever in my mind that this assertion of Welcker's was based upon a skull very inefficiently macerated for we have treated hundreds of adult skulls in precisely this manner and in no case since we adopted the live steam method have we encountered a skull the two halves of which do not exactly correspond.

Welcker's monograph which contains the information upon this topic (62) I have been unable to obtain and I am therefore compelled to use the statements as given by Broca (14). According to Broca, Welcker found that after three successive days soaking in water an adult skull undergoes the following average increases of dimentions; length 0.4, mm., breadth 0.7 mm. height 0.7 mm. In order to identify these increases Welcker had to employ special means of determination since the ordinary instruments do not give such nicety of accuracy. Broca accepted these results of Welcker, and indeed for some time believed that soaking would probably not increase sensibly the capacity since any swelling of the bones might equally tend to decrease capacity by encroaching upon the interior of the cranium. Broca found by computation that the increase of linear dimensions given by Welcker should increase the capacity only 18.98 cc. Later however, by the direct method Broca found an increase of 30 to 40 cc. and even more. Therefore Broca rather diffidently suggests that as even the most experienced investigator finds difficulty in measuring to tenths of a millimeter perhaps some slight error, not amounting in the aggregate to more than 0.3 or 0.4 mm., may have crept into Welcker's estimates. This by Broca's computation would be sufficient to harmonize the difference in actual capacity with difference in linear measurements.

Now there is internal evidence of an error in Welcker's figures for it is manifestly absurd to expect an increase in breadth greater than that

in length, and even though the basio-bregmatic height be employed an increase in height could only appear to be as great as that in length through defective instrumental methods. Until recently I was content to accept Welcker's conclusion that there is no sensible change in these dimensions since that opinion appeared to be confirmed by the close fit of our half skulls throughout the period of drying. Nevertheless, having determined the instrumental errors of our methods I decided to work over this problem once more, especially as I had come to have less confidence in Welcker's other cranial observations. Table X gives the results of this inquiry. It is unfortunate perhaps that these determinations were all made with the old apparatus but I am convinced that they are essentially correct and therefore I do not hesitate to present them for criticism. All the skulls in question had undergone a period of drying for more than a month in the heated atmosphere of the museum before they were used for the second determination; there is no doubt of their final condition; any further shrinkage is extremely unlikely. It must be noted that the average difference is obtained by dividing the total difference by ten and not by subtracting the total dry measurement from the corresponding total moist measurement.

Table X.—Showing the probable average shrinkage of skulls in drying
Male White Skulls

		Length			Breadth			Aur. Height		
Skull	Days of drying	After cutting	After drying	Diff.	After cutting	After drying	Diff.	After cutting	After drying	Diff.
848	73	189	185.5	3.5	145	143.5	1.5	115	112	3.0
856	84	176.5	173	3.5	138	135	3.0	118	116	2.0
865	75	190.5	187	2.5	145	142.5	2.5	114.5	112	2.5
867	67	176.5	174	2.5	142	140	2.0	114	112	2.0
878	87	183	179.5	3.5	149.5	148	1.5	120.5	117.5	3.0
885	64	173	170	3.0	145	142	3.0	115	109.5	5.5
887	36	184	183	1.0	154	150	4.0	116	112.5	4.5
890	36	190	188	2.0	152	150	2.0	108	107	1.0
898	40	187.5	185.5	2.0	154.5	150.5	4.0	116	113.5	2.5
902	36	195	192.5	2.5	144.5	142.5	2.0	117	115	2.0
Average		184.5	181.8	2.6	146.95	144.4	2.55	115.4	112.7	2.8
Prob. Instr. Error				.3			.3			1.0
Prob. Average Shrinkage				2.3			2.25			1.8

The breadth measurements were all taken with Flower's craniometer; length and auricular height with the old apparatus (Fig. 1).

Table X shows an average difference of 2.6 mm., 2.55 mm., and 2.8 mm. for length, breadth and auricular height respectively, as the result of drying. Lest we overestimate this factor the appropriate instrumental

error is subtracted from the figure given. As a result we have an average shrinkage in length of 2.3 mm., in breadth of 2.25 mm. and in height of 1.8 mm. These figures are very different from those given by Welcker and probably come much nearer the truth. The astonishing feature of this shrinkage is that it should be carried out so evenly and symmetrically, the two halves of the skull fitting accurately together throughout the process. There is a great difference between initial drying of the macerated bones and drying from a subsequent wetting. We have learned never to immerse a bone in water once it is thoroughly dry for if it is again soaked the bone may warp, check or even split apart. There is nothing so destructive of bones as alternate wetting and drying. Doubtless many of the bones unearthed showing evidence of cannibalism, of splitting to obtain the marrow, of battles in caves, of being gnawed (without the occurrence of tooth-marks) by wild beasts and of other sensational events are nothing but the result of alternate soaking and drying in the course of time. We are able to produce all these conditions and even the simulation of efforts at trepanning by our routine methods through tricks in maceration and after-treatment.

If the figures for shrinkage be reduced to percentages of the dimensions of the dry skull we have a shrinkage in length of 1.2%, in breadth of 1.8% and in auricular height of 1.6%. The small difference in percentage between the figure for length and those for breadth and height may well be related to the saw-cut in the case of breadth and to the difficulties of actual measurement in the case of height. At least the figures are close enough to indicate that shrinkage is a general property of bone in drying. *There is no reason to suspect that the relative shrinkage is greater in one direction than in another.*

Had Broca possessed such an estimate of shrinkage as I have just presented he would not have been concerned on account of the small resultant change in cranial capacity but rather he would have been at a loss to explain the large amount. The actual determination of shrinkage in capacity determined directly in this laboratory averages 58 cc. as already shown. Suppose we calculate for Broca's type skull by Broca's own method the increase in capacity consequent upon the average increase in linear dimensions as presented in Table X. Broca's type skull had the following dimensions: length 180 mm., breadth 140 mm., basio-bregmatic height 130 mm. His formula may be stated thus:

$$\frac{LxBxH}{2} \div 1.092$$ The result for the type skull is 1500 cc.

Applying the increases stipulated by Welcker as the result of soaking

the capacity equals about 1519 cc. Correcting the several dimensions in accordance with our findings as follows: length 182.3 mm., breadth 142.25 mm, (basio-bregmatic) height 131.8 mm., we obtain as a result 1564 cc. Here is an increase of 64 cc. against an increase on Welcker's data of 19 cc.

We cannot accept Broca's calculation because it is not in accordance with mathematical theory. In this special instance it does come accidently very close to our direct shrinkage average of 58 cc. But we may for a moment anticipate the method which we shall ultimately choose for the computation of capacity in male White crania, namely Lee and Pearson's mean reconstruction formula No. 9. Let us apply this to our skull No. 878, male, White which will serve as a trial. Then by this formula the capacity in the moist skull equals:

$$.000337 \times 183 \times 149.5 \times 120.5 + 406.01 \text{ i. e. } 1517 \text{ cc.}$$

Changing the dimensions in accordance with our averages for drying we would have capacity equal to

$$.000337 \times 180.7 \times 147.25 \times 118.7 + 406.01 \text{ i. e. } 1470 \text{ cc.}$$

Here then is a difference due of 47 cc. due to drying. The difference between the change in capacity determined directly and that calculated from change in linear dimensions upon an average White skull is only 11 cc. It is also interesting but not really significant to observe that there is a difference of only 2.0 cc. between this calculated change in capacity and the volume of the dura as determined directly.

Our investigation has shown clearly there is a real change in capacity consequent on drying and that this change can be reasonably closely approximated by computation from the very real changes which take place in linear dimensions.

LINEAR DIMENSIONS OF THE RESERVE CRANIA

Before entering on a study of variabilities and correlations of the several dimensions of these skulls let us consider the more general features of the collection. Sex and Stock are accurately known; there is no clustering due to the presence of entire families: all measurements and calculations have all been carried out by the one individual with the exception of the few earlier capacities obtained by Dr. Black; the instrumental errors have been fully considered and can therefore be appropriately discounted. These are all to the good. On the other hand some discouraging aspects are present. There is, as always, the possibility of an error in inscribing. Undoubtedly this has occasionally occurred even in the statement of capacities but possibly more frequently

in the linear measurements for they were nearly all made in the evening when the writer was alone at work. A rare mistake of this nature however is unlikely to have any real effect upon the figures here presented. The most disturbing influence lies in the fact that I did not realize the significance of shrinkage in drying as applied to the bones of the cranium. I was willing to accept the assertion of Welcker that although this shrinkage does occur yet it is so insignificant in amount that one cannot measure it by means of the ordinary instruments with any certainty. Only during the past few months have I come to realize the appreciable change in dimensions which a cranium undergoes in drying. In consequence of this failure to make the crucial experiment earlier the following number of skulls have been measured while still in the natural state and included in the series:—White male 10 out of 167; Negro male 14 out of 87; White females one; Negro females none. The question therefore arises as to whether one should have scrapped all the work because of this finding after all the variabilities and correlations had been worked out. I do not think such action is either necessary or justifiable. The primary object of the work was not to establish standards of dimensions or of correlations. For that purpose so small a material would not have justified this work in the first place; when we come to consider possible attributes of sex and stock our entire collection will be thrown into the investigation. This present research had for its goal the verification of Pearson's mathematical method of computing capacity, the inquiry into its validity for individual skulls, and the trial of formulae based upon White material for estimation upon material so divergent from White stock as the Negro is. The questions which I put to myself were; first, can Pearson's formulae be used with advantage upon an entirely different population so heterogeneous withal as is our White series; and secondly, how far can the interracial type of formula be depended upon for computation of capacity upon another human stock. The errors which I have recognized, being fully stated, cannot mislead anyone. They are so rare and so small in the aggregate that their influence upon the result must be scarcely appreciable. If they were appreciable they still would not be able to swing the final figures beyond the legitimate and normal bounds of the random sample. Finally I have shown how these errors will be precluded in the later definitive investigation; without the present preliminary research these errors could not have been found or their approximate magnitude ascertained.

There is still one other point which should receive attention at this time. Many if not the majority of the individuals from whom the crania

in question have been obtained, during life were known to the writer or his colleagues. The laboratory stands in the center of the district of their former activities. Their habits of life, personal details of their character, the experiences they met, all form a part of that floating mass of general information common to a band of workers grouped as are the members of the Anatomical staff about a problem so vast as the study of a great population in the acknowledged center of the American melting-pot. The anatomical laws of Ohio, for the foresight and wisdom of which we owe so much to Dr. Hamann, permit an arrangement by which the municipality recognizes this laboratory as guardian of the mortal remains of the destitute, the strangers and the lost until such time as they may be claimed by those who have a stronger right. This Medical School was quick to recognize the value of so great a trust and has never failed to carry it out to the letter. It is the only way in which by mutual faith and co-operation the public and the anatomical laboratory can share a common responsibility. If in the course of what follows the reader feels that I am treading a little beyond that safe ground on which my figures should guide my steps, I trust he will not imagine that I have failed to realize the low and irregular correlation of cranial characters and the possibility of great divergence from sample to sample. The writer has based his conclusions so far as possible upon correlation with capacity which alone at present encourages some dependence (16, pp. 462-3) and yet in spite of himself it is scarcely likely that some influence from that considerable background of his acquaintance with a problem in which he has lived for years and embraces so many aspects, anatomical and sociological—it is perhaps impossible that some such influence should not make itself felt here and there and sway the writer's mind towards a conclusion which his figures alone would hardly justify.

Table XI gives the results of our investigation relating to linear dimensions and cephalic index of the Reserve material. For comparison I have appended the corresponding figures given by Lee and Pearson for Bavarian and Aino crania and by Benington for his Batetela series.

Our White material is undoubtedly heterogenous in the extreme and in that respect stands in marked contrast with Lee and Pearson's groups. Referring more especially to our male series we note that the most significant feature about our dissecting room material is its relatively low auricular height which amounts only to 116.41 mm. instead of 120.75 mm. in Ranke's Bavarians. Now the standard deviation of our male White auricular height is less than that of the German males, a result quite in accordance with the supposed selective factors of crime, drunk-

enness and moral obliquity already discussed. I do not wish to enter into a consideration of the relation of cranial capacity to "intelligence" at this stage but it is plain that, using the word intelligence in a wide sense, it is to be expected that such material as ours would show a low average. The mean capacity of our male Whites is only 1391 cc. against the average German capacity of 1504 cc. Since our standard deviation of capacity is practically the same as that of a general homogeneous population it is apparent that we are dealing with a group simply of low average capacity and it is rather striking that this is associated with a relatively low auricular height with less standard deviation than that of the German males. Referring to Table XII, we see that the correlation between capacity and height is greatest among our male Whites whereas it is least in the Bavarian crania. It is this high correlation with height in our series which points most insistently to the inference that there is at least something in the popular idea of associating great auricular height with "intelligence" and the reverse condition with poorer mental fiber. One might well anticipate a low correlation in a general population unselected by the factors mentioned.

There is no doubt that the relatively low auricular height of our White males is related to the social stratum from which this material comes. The difference between auricular height in different grades of society is well brought out in Benington's comparison of Royal Engineers with Oxford undergraduates (5 p. 131). Pearson has discussed the problem at length (5 p. 137). Taking the social class represented by members of the British Association, the Anatomical Congress and the University College Staff, Pearson reaches an average height in the living of 131-135 mm. and deduces a probable skull height of about 121 mm. I have no fault to find with this assumption provided another 2 mm. be subtracted for the shrinkage of the skull in drying. Thus we should arrive at a probable mean of 119 mm. or slightly less for the more cultured Western European. This is not unwarrantably high in relation to the figures for general grave-yard populations such as Pearson gives, for it is apparent that the majority of such collections will give the rather low average of the peasant and laboring classes. Compared with figures obtained from the more dolicocephalic type our figure of 116 mm. is even high but it must be remembered that our White population is by no means frankly dolicocephalic, and the more brachycephalic the type the relatively greater is the auricular height.

In our female Whites again one finds a correspondingly slight auricular height with relatively high correlation. I have not thought it

worth while to calculate cephalic index for the small female series. The primary purpose of this work is to inquire into the validity of computation of capacity by mathematical methods and there are included therefore only those crania the capacity of which has been directly determined. In a future communication it is my intention to present data for the much larger complete series of skulls.

Passing to our Negro material we note a converse situation in respect of height. In this case I have certain reasons for believing that we are dealing with a fair average of the entire Negro population. The social selective factors are entirely different from those effective among the Whites. In harmony with these sociological assumptions there appears to be a striking approximation in the mean capacity to that predicted from African material by Pearson, especially in the case of the males. Among our males we find the mean auricular height almost 2 mm. greater than that for the Batetela and the standard deviation is very great. It far surpasses any other standard deviation in these tables of comparison. Our male Negro skulls are larger in all dimensions than the Batetela although the average cranial capacity is not correspondingly great. Judging simply from the figures presented one might conclude that in a population at large the greatest cranial variation occurs in auricular height. It is true that our female Negro series does not confirm the evidence of the males but this group is so small that it can have no real significance in this regard.

Comparing the male series, there is somewhat less variability in our Negroes than in our Whites except in the case of auricular height. Probably this greater variability of the Whites is related to the markedly heterogeneous character of the White population. We see once more an indication of this theory in the greater correlation of linear dimensions with capacity in our Negroes.

The absence of any correlation between length and breadth in our male White crania together with the approximately similar correlation of these two dimensions with capacity still further indicate mixed character. Contrast this situation with the condition in the male Negroes. In the latter there is much greater correlation of both length and breadth with capacity and there is fair correlation between length and breadth themselves. The greater correlation of length with capacity in the Negroes apparently falls into line with Lee's suggestion that this may be a distinguishing mark of dolicocephalic races; no evidence of such a nature could be expected from our Whites.

The relatively stable auricular height of the Whites and the very

variable height of the Negro crania again comes out in the correlations of height with length and breadth. So far as cephalic index and capacity are concerned there is no correlation whatever.

TABLE XI.—THE LINEAR DIMENSIONS AND CEPHALIC INDICES OF THE RESERVE MATERIAL COMPARED WITH THOSE OF THE GERMAN AND AINO GROUPS USED BY LEE AND PEARSON AND WITH BENINGTON'S BATETELA SERIES

Reserve Crania

Race or Stock	Sex	No.		Mean	Standard Deviation	Coefficient of Variability
White	M.	167	Length	181.42 ± .427	8.191 ± .302	4.514 ± .166
			Breadth	144.28 ± .296	5.675 ± .209	3.933 ± .147
			Height	116.41 ± .252	4.822 ± .178	4.142 ± .152
			Cephalic Index	79.69 ± .247	4.743 ± .175	5.951 ± .219
White	F.	31	Length	173.71 ±1.036	8.559 ± .733	4.927 ± .429
			Breadth	139.40 ± .648	5.355 ± .458	3.841 ± .328
			Height	112.29 ± .414	3.424 ± .293	3.048 ± .261
Negro	M.	87	Length	186.2 ± .471	6.515 ± .333	3.498 ± .178
			Breadth	139.3 ± .409	5.660 ± .289	4.063 ± .207
			Height	115.5 ± .777	10.746 ± .549	9.303 ± .475
			Cephalic Index	74.89 ± .226	3.130 ± .160	4.179 ± .213
Negro	F.	17	Length	179.23 ± .757	4.631 ± .535	2.583 ± .338
			Breadth	136.41 ± .659	4.031 ± .466	2.955 ± .341
			Height	112.20 ± .789	4.824 ± .558	4.298 ± .497
German	M.	100	Length	180.58	6.088	3.371
			Breadth	150.47	5.849	3.887
			Height	120.75	5.397	4.469
			Cephalic Index	83.30	3.500	4.201
German	F.	99	Length	173.59	6.199	3.571
			Breadth	144.11	4.891	3.394
			Height	114.17	4.463	3.909
			Cephalic Index	83.10	2.973	3.578
Aino	M.	87 or 76	Length	185.82	5.936	3.195
			Breadth	141.23	3.897	2.759
			Height	119.32	4.377	3.668
			Cephalic Index	76.50	2.392	3.127
Aino	F.	63 or 52	Length	177.17	5.453	3.077
			Breadth	136.79	3.662	2.677
			Height	114.97	3.651	3.175
			Cephalic Index	77.40	2.440	3.152
Batetela	M.	47 or 50	Length	177.78	6.80	3.82
			Breadth	138.52	5.00	3.61
			Height	113.85	4.05	3.56
			Cephalic Index	77.99	2.58	3.31
Batetela	F.	26 or 27	Length	171.23	5.26	3.07
			Breadth	130.91	5.53	4.63
			Height	109.00	4.35	3.99
			Cephalic Index	76.46	2.50	3.27

TABLE XII.—COEFFICIENTS OF CORRELATION. RESERVE MATERIAL

Measurements		Male Whites 167	Male Negroes 87
Capacity and length	r_{01}	.4589 ± .0412	.6703 ± .0398
Capacity and breadth	r_{02}	.4693 ± .0407	.6449 ± .0422
Capacity and height	r_{03}	.5913 ± .0339	.2616 ± .0673
Capacity and cephalic index		—.0667 ± .0519	.0687 ∓ .0721
Length and breadth	r_{12}	—.0045 ± .0522	.3789 ± .0619
Length and height	r_{13}	.2667 ± .0503	.1563 ± .0705
Breadth and height	r_{23}	.3012 ± .0497	.2357 ± .0682
		Female Whites 31	**Female Negroes 17**
Capacity and lenth	r_{01}	.3729 ± .1211	.5028 ± .1414
Capacity and breadth	r_{04}	.5684 ± .0996	.7436 ± .1094
Capacity and height	r_{03}	.6067 ± .0963	.7196 ± .1136

Lee and Pearson's Material

Measurements		Male German 100	Male Aino	
Capacity and length	r_{01}	.5152 ± .0495	.8928 ± .0157	
Capacity and breadth	r_{02}	.6720 ± .0370	.5606 ± .0531	
Capacity and height	r_{03}	.2431 ± .0635	.5444 ± .0544	76
Capacity and cephalic index		.2022 ± .0647	—.3069 ± .0701	
Length and breadth	r_{12}	.2861 ± .0619	.4316 ± .0588	
Length and height	r_{13}	—.0975 ± .0668	.5008 ± .0542	87
Breadth and height	r_{23}	.0715 ± .0671	.3454 ± .0637	
		Female German 99	**Female Aino**	
Capacity and length	r_{01}	.6873 ± .0366	.6627 ± .0525	
Capacity and breadth	r_{02}	.7068 ± .0339	.5021 ± .0700	
Capacity and height	r_{03}	.4512 ± .0540	.5210 ± .0681	52
Capacity and cephalic index		—.0307 ± .0677	—.2466 ± .0878	
Length and breadth	r_{12}	.4876 ± .0517	.3765 ± .0729	
Length and height	r_{13}	.3136 ± .0611	.3489 ± .0746	63
Breadth and height	r_{23}	.2764 ± .0626	.1778 ± .0823	

Benington's material—Correlations by Isserlis.

	Male Negroes 110	Female Negroes 81
Capacity and length	.7433	.6699
Capacity and breadth	.4977	.7578
[Capacity and total height	.6080	.5450]

THE CALCULATION OF CAPACITY FROM KNOWN DIMENSIONS

Sufficient allusion has previously been made to difficulties in the way of determining capacity directly in a manner which will inspire confidence in the result. In our own laboratory, as I have shown, two trained observers using the same method and the same instruments, but without previous conference upon details, can consistently obtain results some 50 cc. apart. I have not attempted to decrease the personal equa-

tion between these two observers because it is this very personal error which I desired most to investigate, in order to control the comparison of results obtained by two observers upon different material. Some writers have been more optimistic than I, but I think it should be admitted that the personal equation does not permit a comparison for individual skulls within less than about 40 cc., providing the capacity is determined by independent investigators who are not working upon the same problem and trying of set purpose to get the same result. Whatever direct method is employed I do not believe that figures can be depended upon to a greater extent than this.

If the assumptions of the preceding paragraph be accepted there is ample need for the use of some method which will give greater confidence. Now the linear dimensions of a skull are vastly more easily obtained than the capacity and therefore it follows that if we can get a sufficiently close approximation to probable capacity by the employment of mathematical methods, using linear dimensions as a working base, we shall have a result at least comparable with those of other workers also using the method in that it eliminates the very large personal error inseparable from the direct method of determining capacity.

In approaching the problem from the mathematical standpoint we have certain important points to bear constantly in mind. The method must be in accordance with mathematical theory and we must know, at each step, the probable error of the method itself. We must know how far we may depend upon the method when applied over a range covering individual variation, age, sex, race and human Stock. We must know how far the result is going to be influenced by instrumental errors in determining linear dimensions and by the physical condition of the skull itself. The most significant of the physical conditions is naturally related to the degree of humidity in the skull. I propose then to touch upon each of these subjects in turn.

To be in accordance with mathematical theory and to check off, as we go along, the probable errors of the method itself it is necessary to lay on one side the several suggestions already made by various investigators and discussed in a previous section of this paper. The only method which is really valuable is that developed by Pearson, and this, furthermore, is the only possible method. The scientific theory is fully explained by Professor Pearson himself and to his paper (39) the reader is referred, but there are a few matters on which the general reader who does not desire to concern himself with details must inform himself. They may be briefly stated in the following manner. Reconstruction of capacity by

either a regression or a least square formula can never be expected to be quite accurate; it is an approximation correct within certain limits, the limits being fairly wide in the case of individual skulls, but narrower for the mean of a series, the exactitude varying with the square root of the number in the series. The accuracy of prediction is not indefinitely increased by increasing the number of dimensions upon which the prediction is founded. In the case of capacity three measurements will give all the accuracy which can be obtained by calculation; it has already been shown why the measurements chosen should be greatest length, greatest breadth and auricular height. Both in theory and practice the multiple regression formula based upon several dimensions will give a more correct prediction of capacity than will the mean of several regression formulae each based upon one only of the chosen series of dimensions. That individual variation greater than the racial difference should occur in the dimensions is of itself no bar to use of the formula based upon one race for the prediction of capacity in another race, but if this be done it must be expected that the error will be greater in proportion to the fundamental differences which exist between the dimensions employed and the measurement, in this case capacity, to be predicted.

TABLE XIII.—FORMULAE CALCULATED FOR THE RESERVE MALE WHITE AND MALE NEGRO SERIES. CAPACITY IS IN CC.; LENGTH, BREADTH AND AURICULAR HEIGHT ARE IN MM.; N IS THE NUMBER FROM WHICH C IS CALCULATED; I MEANS CEPHALIC INDEX.

Male White		Male Negro	
1. $C = 6.59\ L + 195.44$	$\pm \frac{67.76}{\sqrt{n}}$	1. $C = 13.198\ L - 1107.47$	$\pm \frac{64.14}{\sqrt{n}}$
2. $C = 9.73\ B - 12.84$	$\pm \frac{67.38}{\sqrt{n}}$	2. $C = 14.600\ B - 683.78$	$\pm \frac{66.04}{\sqrt{n}}$
3. $C = 14.43\ H - 288.65$	$\pm \frac{61.50}{\sqrt{n}}$	3. $C = 3.118\ H + 989.88$	$\pm \frac{83.43}{\sqrt{n}}$
4. $C = -1.65\ I + 1521.48$	$\pm \frac{76.15}{\sqrt{n}}$	4. C Not computed	
5. $C = 5.119\ L + 7.357\ B + 9.539\ H - 1709.49$	$\pm \frac{58.90}{\sqrt{n}}$	5. $C = 7.211\ L + 9.958\ B + 0.956\ H - 1490.26$	$\pm \frac{87.74}{\sqrt{n}}$

I have drawn up Table XIII which gives the formulae calculated for our male White and male Negro series. The female series are too few to warrant the time necessarily spent in actual calculation for even had their formulae been worked out there could not be placed upon them any reliance in a critical estimate of their value. Now in a general way it will be noticed that the several formulae reflect the correlation figures

already presented in Table XII. For example, there is no correlation between cephalic index and capacity in either of our series. The appropriate formula for the Whites shows practically no reliance placed upon index so that it resolves itself into a single constant with a high probable error. I have therefore not attempted to develop this particular formula for the Negroes. On the other hand the high correlation in the Negro between capacity and length or breadth is shown in the relatively great emphasis laid upon these two dimensions in the regression formulae 1. and 2. for the Negro. The low correlation of capacity with height in the Negro is reflected in the comparatively small reliance upon height in formula 3. and the high probable error. The same features may be noted in the formulae for the Whites; there is more reliance upon height which has a somewhat high correlation with capacity than upon length or breadth for both of which the correlation is lower. Again in the regression formulae 5. for each series there is greater reliance upon those measurements for which the correlation figure is higher. This is naturally better marked in Negro 5. than in White 5.

Table XIV.—White males. Differences between measured and calculated cranial capacity

Skull	Water Method	W. R. U. 5.	P. and L. G. male 8	P. and L. Mean 9	P. and L. G. male 9	P. and L. 10 bis.
800	1305	— 1	+ 11	+ 36		
801	1662	—100	— 64	— 61		
804	1350	+ 45	+ 67	+ 83		
805	1400	0	+ 45	+ 46		
806	1275	+ 42	+ 88	+ 72		
810	1260	+ 63	+ 81	+107		
819	1500	— 24	+ 31	+ 16		
821	1425	— 3	+ 54	+ 35		
823	1307	— 29	+ 44	+ 70		
826	1182	+ 28	+ 71	+ 96		
828	1567	— 97	— 71	— 58	— 63	— 35
832	1335	— 75	— 76	— 25	— 25	— 11
833	1437	— 61	— 68	— 25	— 37	— 22
834	1542	— 83	— 30	— 35	— 40	— 11
836	1472	— 4	+ 25	+ 35	+ 30	+ 58
838	1390	+ 85	+122	+126	+121	+150
841	1407	— 28	— 6	+ 13	+ 10	+ 28
843	1375	— 85	— 63	— 43	— 43	— 37
844	1490	+ 32	+ 31	+ 74	+ 68	+103
848	1410	+ 12	+ 66	+ 58	+ 54	+ 77
Actual mean error		44.85	55.70	55.70	49.1	53.2

Now one of our main problems in this investigation was the determination of how far one is justified in depending upon the result of calculation based upon our own series for an estimate of the cranial

capacity of individual skulls in our own series. The result is shown for male Whites in Table XIV and for male Negroes in Table XV. Let us examine the former first. I have chosen at random twenty well dried skulls of which the capacity was measured long before this critical review was undertaken though not indeed before it was projected. It is to be remembered that we have the advantage of possessing the skulls themselves and can therefore turn back to each and study it in the light afforded by this table. It should also be recalled that the difference between the direct determinations of two trained workers in this laboratory is approximately 50 cc. The actual mean error of computation by means of our White formula 5., is only 45 cc., less than the divergence between the direct results of Dr. Y. and myself. Ignoring in the table those divergences of less than 16 cc. which I have shown is the probable approximation to the truth of my own direct estimates we find nine cases where the calculated figure is too low and six in which it is too high. Referring to the skulls themselves and their data I find that the majority of the former are either under forty-five and therefore comparatively thin, or unusual in shape in that they are very brachycephalic or of great auricular height. The only exception is No. 834 which has a low vertex and for the discrepancy in which I cannot at the moment account. No. 801 in which the divergence is very great is an extraordinarily thin cranium, and No. 828 has the unusual auricular height of 121 mm.

Turning to the six in which the computed figure is too high we find that three are sixty years old or over with thick cranial walls, two are thirty-five and forty-three respectively with prematurely thick skulls and one, No. 826, has so curiously formed a skull that I took him to be a lunatic from the State Hospital until I found, by his record, that he was a tuberculosis patient in our own wards in City Hospital.

Table XV.—Negro males

Skull	Water Method	W. R. U. 5	P. and L. Aino male 8	P. and L. Mean 9
777	1440	—156	— 93	— 81
778	1205	+ 79	+140	+150
779	1430	+ 35	+165	+112
782	1465	—105	— 38	— 31
814	1252	+ 56	+ 99	+131
815	1285	+ 45	+186	+ 88
825	1110	— 28	+ 17	+ 55
831	1370	+ 30	+179	+100
835	1460	— 16	+ 99	+ 73
842	1287	+ 59	+194	+106
Actual mean error		60.9	121.0	92.7

If, instead of the above segregation, we investigate only those skulls the computed figure of which diverges from the directly ascertained figure by more than the average amount, there is in each case some quite obvious reason why this divergence should be found. Thus the detailed investigation of the skulls themselves merely gives added confidence in the computed figure and the hope that, by substituting internal measurements for the external in a later research, the computed figure will be fully vindicated.

In the case of the male Negroes I have taken only ten skulls at random and it is disappointing to find that the actual mean error, contrary to my expectations, is 61 cc., and therefore much greater than in the White series. The reasons for this divergence I will discuss immediately. Taking simply the three in which the computed figure differs greater from the directly ascertained capacity I find that Nos. 777 and 782 are of age about 30 and age 23 respectively, very thin skulls and unusual in shape for the Negro. Both have a high frontal region and a high occipital region like the Whites. The third, No. 778, though only twenty-eight years old, is an extraordinarily thick skull such as one occasionally finds in young Negroes.

It is imperative at this juncture to look into the reason for the high mean error in the Negro series. The series is small to begin with. The coefficients of variation for linear dimensions of the Whites are between 3.9 and 4.6. Whereas the coefficients for length and breadth of the Negro skulls are 3.5 and 4.1 respectively, that for height is 9.3, a very marked difference and one bound to have some effect upon the accuracy of the formula for individual skulls. Add to these features the fact that thickness in the Negro skull varies very much more than in the White cranium and also the fact that the contour of the Negro skull in many individuals, at least in America, presents frontal and occipital variations totally unlike any variation in the White either in type or degree and we have, I am sure, sufficient explanation of the relative inadequacy of the formula compared with that for the Whites. This whole question of the contours of the Negro skull is a very promising one for future investigation and may throw considerable light upon the problem of Negro-White hybrids. In this work the contour maps drawn up by Benington (5) should prove of great value.

It will be noted that I have not attempted to forecast capacity from a single linear dimension. This has already been done by Lee (28) with results so inferior to those obtained by the use of a multiple regression

formula calculated from all three dimensions that no further proof of its inadequacy is necessary.

To sum up the foregoing paragraphs it may be stated that for individual skulls of even a heterogeneous White population, a regression formula based upon this heterogeneous population and involving three linear dimensions comparable with those obtainable upon the living head, may be used to obtain an estimate of capacity which is, with few exceptions, not far without the range of error of two observers working upon the same series of skulls by the direct method. It may further be stated that the average mean error falls actually within the standard just set up, and although the mean error of the computed estimate is greater than the error of one observer (myself) upon a single skull, yet it is not much greater than the error of the same observer working with dry skulls by the water method or the error of observation by the seed method upon dry skulls according to Bartel's findings.

One will naturally inquire what is the probability of this exactitude being improved upon in future work. Referring to Lee and Pearson's monograph we find that, for a homogeneous population, working with a multiple regression formula based upon that same population (Ranke's Bavarians), these investigators found a mean actual error of 60 cc., and for another homogeneous White population (Koganei's Ainos) a mean actual error of 55 cc. Both these series were smaller than ours but they had at least the undoubted merit of homogeneity. It was not possible for Lee and Pearson to refer back to the original skulls of their series and so to correct any errors on the anatomical side, errors which those who have worked with figures in relation to anatomical material know well creep in occasionally in spite of the utmost vigilance. When for instance I see discrepancies between the computed figure and the directly determined capacity so great as those of skulls 2. and 9. in Lee and Pearson's Table XI and the skulls 1, 4 and 18 in their Table XIII, I am led to infer that there is something significant, not in the mathematical work but in the anatomical side of the investigation. Either there is a gross uncorrected error in the anatomical observations or there is a very important anatomical or pathological condition present in that particular skull which should be investigated. Now as our series grows and as the workers realize more and more the need for the utmost vigilance in controlling possible anatomical errors, especially in the strenuous rush and constant interruption which are inevitable in the conduct of an active laboratory where teaching and investigation are inextricably mingled, there is every hope that the mean actual error,

already reduced by some 10 cc. will be reduced still further. I have already pointed out that the prediction can only be an approximation and Pearson has emphasized the fact that, in view of variability in individuals and races, any formula which professes to reconstruct the desired measurement with extreme accuracy may at once be put aside as unscientific (39). Consequently the reader must not get the idea that I expect to obtain an approximation in which the error will be reduced more than a few cubic centimeters. Nevertheless even this is worth striving for since we have already reached an accuracy comparable with that obtained by direct determination and devoid of a personal factor which must itself be considerable.

THE CALCULATION OF CAPACITY FROM A FORMULA BASED UPON ANOTHER POPULATION OF THE SAME STOCK

It is evident that estimation of capacity by the mathematical method cannot be of general service unless one has assurance that the formula based upon one large series is applicable to skulls of an entirely different series. It would not be possible, were the time necessarily consumed justifiable, to work out a formula for the series of skulls to be found in every laboratory. In the main the available series are small and very heterogeneous and workers will naturally feel some diffidence in applying to individual skulls of their own series a formula based upon quite other material. Pearson and Lee have taken up this problem and to their results we shall revert shortly. For the moment let us examine the figures which have been obtained in experiments of this nature in our own laboratory.

In order to test the wisdom of such application I have calculated capacities of certain of our White male skulls by various formulae deduced by Lee and Pearson in their investigation. These figures are gathered together in Table XIV. The nearest to our White male formula 5. is Lee and Pearson's German male regression formula 8. This German population possesses a mean head length slightly less than ours, a breadth considerably greater and therefore a somewhat higher cephalic index. Our standard deviation of length is greater than that of the Germans but our standard deviations of breadth and height, in spite of the heterogenous nature of our population, are less. On the whole our population is more nearly comparable with these male Germans than with any other for which formulae have been constructed. The cranial capacity of the Germans is much greater than that of ours and it must therefore be expected that a formula based upon them will tend to give

higher values than our male White formula 5. As matter of fact this expectation is found to accord with the figures in Table XIV where Pearson and Lee's male German formula 8. gives a mean actual error of 56 cc. as against the mean actual error of 45 cc. from our male White formula 5. In a very general way Pearson and Lee's formula gives a value about 40 cc. higher than ours.

I have not attempted a formula based upon least squares like Lee and Pearson's No. 9. This can be done later when our series is larger, now that our confidence in the mathematical method is firmly established. The least square formula for the male Germans gives a better result for our population than the regression formula for its mean actual error is 49 cc. instead of 56 cc. Hence using a least square formula based upon a totally different population, and to a certain extent a different race, but of the same Stock, we obtain results the mean error of which is only about 4 cc. greater than the error of our own formula based upon our own population. This is a very important confirmation of the statement of Lee and Pearson that "within the limits of error occurring in reconstructing capacity formula 9. as found for any race may safely be used to calculate the capacity of an individual of a different race." These authors conclude with justice that an average error of about 3–4% is all that will be made in applying a least square formula to determine the cranial capacity of any individual not necessarily of the same race. I want particularly to emphasize the word *race* in this connection because I shall shortly show that one may not apply a formula with the same assurance to an individual skull of another human Stock.

To test still further the possibility of application of formulae to individuals of another race I have calculated capacity upon a random series of our male Whites by Lee and Pearson's mean least square formula for individual crania (see 29 p. 390) and also by their inter-racial formula (see 29 p. 386). To use this last is perhaps hardly permissible in theory but it was at least interesting to see how results from it would compare with those obtained by the other methods adopted. The former formula was obtained by averaging the corresponding formulae for males of the German, Aino and Naqada races ((28 p. 243). By this formula the mean error on our male White skulls is 56 cc., precisely the same as that obtained by the multiple regression formula for the male Germans. Considering the fact that this formula is actually based upon three series of skulls which however homogeneous in themselves, represent an inter-racial variation far greater than is to be found in the heterogeneous

series upon which our formula 5. is constructed, it is quite encouraging to find results so good.

The reason for using Lee's formula 10 bis (28 p. 247 foot note) which is computed from the mean linear dimensions of a varied group of races, is quite simple. I propose to test a formula based upon European races in the investigation of so different a Stock as the Negro and therefore I desired to see with what accuracy a formula based upon very divergent races can be employed for capacity determination of White skulls. Here then is a formula based, not indeed upon the dimensions of individual skulls, but upon racial means from the following divergent series: Aino, Malay, Bavarian, Egyptians ancient and modern, Naqada and Etruscans. This is about as varied a mixture as one could hope for, far greater than the variation expressed in the mean reconstruction formula 9 which I have called Mean 9 in Table XIV. Hence, in spite of its being an inter-racial formula I have judged its use worth while. The result obtained is actually somewhat better than that of Mean 9, though naturally not so satisfactory as the result from German male 9.

The experiments just recorded seem to give the necessary assurance that it is perfectly feasible to employ a formula based upon individual skulls of one race for the estimation of cranial capacity in individuals of another race, always presuming the same Stock. Lee and Pearson, investigating this same problem, found that whereas capacity for individual German males calculated from the least square formula based upon these same German males gave a mean actual error of 55 cc., the use of the corresponding formula for male Ainos gave an actual mean error of 57 cc. The difference is insignificant. We note further that the mean actual error of the multiple regression formula upon the Bavarian skulls is 60 cc., whereas the same formula employed upon our own male Whites gives a mean actual error of 56 cc. This is even better than for the Germans themselves. Of course the racial difference between our White skulls and the Bavarians skulls is very much less than the difference in the two series of Lee and Pearson just cited, but it serves to strengthen our confidence in the result, and confirms the statement made by Lee that the general rule for obtaining the best result is certainly to use the formula for the most closely associated race.

THE CALCULATION OF CAPACITY FROM A FORMULA BASED UPON ANOTHER HUMAN STOCK

We have seen how the mathematical method may be employed over a wide range of individual and racial variation, but we have been care-

ful to define Race to the limits of one single Stock. We are not yet ready to discuss the application over an age range although this subject has been lightly touched upon in passing. Lee and Pearson have proved the inadvisability of ignoring sex which has a most important bearing upon the formula. Our next inquiry is one of the most crucial. Is it permissible to apply the formula of one series to individuals of another Stock. We have just seen that by using an inter-racial formula of very diversified peoples and some differences in Stock it is yet possible to obtain fair results even upon a small group. The individual divergences from the ascertained value may show a relatively considerable range of variation but the mean error is not large.

The problem under discussion has been approached by Isserlis (25) who has shown that the mean German capacity can be fairly closely approximated by the use of a least square formula based upon very divergent groups of Negroes, and conversely, that the mean Negro capacity can be fairly estimated by a least square formula based upon the Germans. Upon a mathematical basis Isserlis holds that, "there is no appreciable difference in the thickness of the Negro skull as compared with the European." In this Isserlis is clearly referring once again to mean racial values. It is a matter which will bear further investigation. I have touched upon thickness of the Negro cranium in passing earlier in this communication and I do not desire at this time to sidetrack the main issue which may or may not be influenced by consideration of thickness. This detail I shall leave for later inquiry. The real problem is the application of European formulae to estimation of cranial capacity in individual Negroes. May we accept the application of formulae based upon one stock to individuals of another Stock. Isserlis has done this for racial means with fair results.

To gain some light upon this important matter I have calculated capacity upon ten Negro male skulls by Lee and Pearson's formula, Aino male 8, and Mean reconstruction 9. The results are presented in Table XV. No explanation is needed for the employment of the least square mean formula 9.; it is the formula which one would naturally use for individual skulls for which one does not know the evolutionary history. The multiple regression formula 8. for the male Ainos was chosen in accordance with the principle that one should adopt wherever possible a formula based upon the most closely related race available. Now it is not suggested that there is any close relation between our Negroes and the Aino but the latter is considered to be a primitive race near the evolutionary starting point of the Europeans. And Pearson has deduced

from his studies (6) that the Congo-Gaboon type with which our Negroes are undoubtedly originally associated is a lower branch of the stem which unites Europeans and Negroes together through some trunk type near to which the Aino probably stands. If then we are to choose a White type for comparison with our Negroes it is plainly the Aino which we should use.

Now from the figures presented it is apparent that, although our own formula gives a greater mean error than the corresponding formula based upon our male Whites gives for the male Whites themselves for reasons already discussed, yet both the European formulae give still worse results. The mean error of our own formula Male Negro 5. is 61 cc. but that of the male Aino regression formula 8. is 121 cc. So large an error altogether rules out the use of the latter formula. The mean reconstruction formula 9. of Lee and Pearson stands intermediate between the other two since its mean error is 93 cc., again far too large for actual employment of the formula. The least square formula gives a more fluctuating error but both it and the Aino regression formula are based upon skulls of greater capacity, with fundamentally different relations of capacity to linear dimensions, and of a totally different build. It is interesting to note the average of these ten skulls as deduced from the different methods. They are the following: Direct determination 1330.4; W. R. U. male Negro 8. 1330.3; P. and L. male Aino 9. 1425.2; P. and L. mean reconstruction 9. 1400.7.

The mean cranial capacity of our male Negroes is 1350 cc. Estimating the mean capacity from our Negro formula 5. using the mean linear dimensions we obtain the figure 1350 cc. If instead the male Aino formula 8. be employed we get 1448 cc. and from the mean reconstruction formula 9. we obtain a mean capacity of 1416 cc. Thus it is impossible to confirm the good result obtained by Isserlis in substituting German and Negro formulae for each other. There is internal evidence however which enables us to understand why Isserlis got such excellent results. I have pointed out repeatedly that the cranial capacities in the University College series are larger than our capacities and there is the tendency therefore for these formulae to give a higher result then ours. Now it so happens that Benington's Gaboon skulls have a high mean capacity, high at least for the Negro whose true mean capacity is, as Pearson suggests, not far from 1350 cc. The Gaboon skulls of series 1864 have a mean capacity given by Benington as 1381 cc. and by Isserlis as 1379 cc.; the Gaboon skulls of 1880 have a mean capacity of 1447 cc. These unusually high averages give what is probably a fictitiously high mean

capacity for the negro skull, namely 1375 cc. Using an inter-racial least square formula based upon European racial means and involving not the auricular height but the basio-bregmatic height, Isserlis found a mean capacity for the mixed Negro groups of 1400 cc. This is only 25 cc. greater than the actual average which however we have seen is itself misleadingly high. It is not unexpected therefore that this author, employing a least square Negro formula based upon these skulls of unusually great capacity, should obtain a mean for the male Bavarians less than 10 cc. below the actual mean of 1504 cc. I have calculated the mean capacity for our male Whites, which have the very low average of 1391 cc., by our Negro formula 5 and I obtain a figure of only 1366, that is 25 cc. too low. After all this is merely the same amount too low for our Whites as Isserlis got too high for his Negroes. Nevertheless this mean racial difference tells us nothing of the suitability of the formula for calculating individual capacities. It is essential to try the formulae out for individual cases as I have done. Then we see clearly that one may not apply a given formula to individuals of another Stock, a result in perfect accordance with what one would expect from the differing cranial contours of the White and the Negro stocks. Not only are many Negro crania more developed in the vertex than in the frontal and occipital areas, but they have also transverse and horizontal contours very different from those of the White and it is therefore inconceivable that the constants in a regression formula should not vary considerably from Stock to Stock. To illustrate this truth in another way I have calculated our mean Negro male capacity from Lee's inter-racial European formula 10 bis and get a result of 1430 cc. which is greater than the actual value, 1350 cc., by 80 cc.

From this discussion it follows that one of the most urgent tasks to be performed when our Negro series shall have grown to a number which can be employed with greater confidence is the calculation anew of suitable formulae for the estimation of capacity comparable with those for which we are so greatly indebted to Professor Pearson and his co-workers. In making this statement I realize quite clearly the advantage of the least square formula and the possibility that, by employing this, Isserlis might have greater success in calculating from Stock to Stock than I have had with a regression formula. The least square formulae constructed by Isserlis are not available for our present work since they involve basio-bregmatic and not auricular height. It is true that the constants in the least square formulae vary less from race to race than do the constants of the regression formulae (28 p. 253). Hence if any

formula is to be applied in this way it should be a least square formula. It must not be forgotten however that one of the fundamental objects of our work in this laboratory is the investigation of the American Negro. In view of this we must make every effort to determine precisely how he differs from the White and there is therefore a natural aversion to a formula which glosses over the difference. Both sides of the problem must be studied mathematically just as sincerely as the anatomical comparisons and contrasts must be made.

FICTITIOUS ACCURACY AND THE NATURAL STATE OF THE CRANIUM

A special problem has developed during the course of this investigation and since it is unlikely to occur again now that a definite warning has been given, a short discussion is not out of place. I have previously stated that, relying upon the researches of Welcker, we did not pay particular attention to the physical condition of the skulls when their linear dimensions were taken. In consequence there are ten male White skulls and fourteen male Negro skulls which have been measured (and included in the series) before drying out.

I have spoken several times of the low cranial capacity of our White males, especially in comparison with Ranke's Bavarians. It is therefore instructive to note the mean capacity of these Bavarians as computed by our male White formula 5. and also the mean capacity of our White males as estimated by means of Lee's male German formula 8. By our formula the Bavarians would have a mean capacity of 1474 cc., actually 30 cc. below the correct value whereas our White males by Lee's formula would have a capacity of 1420 cc., in reality 29 cc. above the true figure. It may be that this is due to the greater thickness of our skulls but in any case it is unwise at present to speculate upon the matter; the fact remains. The last ten skulls of our male White series were measured in the natural state (i.e. fresh from the dissecting room). In view of the assertions just made this should give them, by computation, a capacity value greater than is really the case. It so happened that these were the first skulls which I used to test out the reliability of various formulae and it was only when I saw the quite impossible results that I realized our error in trusting to Welcker's observations upon shrinkage in drying. I have inserted the figures obtained in the discarded work upon these skulls as Table XVI, because I think they show, as no other figures could show the influence of the natural state of the skull upon estimates of capacity. I cannot say why it happens that almost invariably these skulls have a capacity greater than is called

for by our formula No. 5. for male Whites. This is at best an accident although it may possibly have some relation to changed social conditions in the city after the war. However, putting upon one side the sociological aspect, we are to note that these skulls were measured fresh from the dissecting room, unmacerated. They therefore correspond to living heads with the soft superficial parts entirely removed. All soft tissues over the cranium and in the external auditory canal were carefully stripped away before the linear dimensions were obtained.

TABLE XVI.—WHITE MALES—MEASURED IN NATURAL STATE

Skull	Water Method	W. R. U. 5.	P. and L. G. male 8	P. and L. Mean 9	P. and L. G. male 9	P. and L. 10 bis
856	1337	— 2	—14	+ 38	+ 36	+ 48
865	1462	—37	+22	+ 18	+ 6	+ 27
867	1380	—54	—34	— 11	— 13	— 2
869	1397	—28	—16	+ 17	+ 14	+ 31
870	1352	—51	—10	— 1	— 2	+ 6
878	1545	—68	—35	— 28	— 23	— 4
879	1305	—45	—77	— 3	— 3	0
882	1452	—13	+18	+ 16	+ 12	+ 35
884	1345	—35	0	+ 7	+ 6	+ 15
885	1270	+70	+88	+108	+107	+119
Actual mean error		40.3	31.4	24.7	22.2	28.7

Comparison of the several columns and their mean errors in Table shows that the mean error for our own formula 5. is little affected, much less than one might expect. This is due I think to the accident of the sample. What is striking is the apparent relative accuracy of the various University College formulae compared with the figures resulting from our own. This was both startling and very puzzling until I realized in the first place, that all these formulae tend to give a higher value than ours, and in the second that there might be a gross uncorrected error in the linear dimensions of our skulls owing to their having been measured in the natural state. Comparison of Tables XIV and XVI shows how false are really the figures in the latter.

I will not labor this matter further: consideration of it brings us directly to two other problems, namely the influence of inaccuracy in linear dimensions upon the estimate of capacity, and secondly, the estimate of cranial capacity upon the living.

THE INFLUENCE OF INACCURACY IN LINEAR DIMENSIONS UPON ESTIMATES OF CRANIAL CAPACITY

In previous pages I have dwelt at length upon the marked effect which personal errors may have in direct determinations of cranial

capacity. I have pointed out that no method is really serviceable unless these personal errors can be eliminated. And further I have shown how, by utilizing the methods introduced by Pearson and his co-workers we may attain the end which we are seeking. Now the personal error in direct determination by any method may be 50 cc. and certainly not less than about 40 cc. It is worth while then to note what an error of this magnitude means in relation to linear dimensions. I have shown the personal error in taking linear dimensions to average about 0.3 mm. for each of length and breadth, and between 0.2 and 1.0 mm. for height according to the method adopted. But in a previous section I have pointed out that the reduction in capacity during drying amounts to about 50 cc. and it is unlikely that further investigations will change this figure to any great extent. This reduction of some 50 cc. in capacity calls for a total change in linear dimensions of about 6.4 mm. which is obviously far more than is ever likely to be the difference between the sum of the measurements of the three dimensions as taken by two observers however new to the work these observers may be. We are then taking less chance of error by using a good mathematical formula upon dimensions taken by even an inexperienced worker than we are if we adopt the direct determination elicited by an observer of much greater experience.

PRECAUTIONS IN THE CALCULATION OF CAPACITY FROM LINEAR DIMENSIONS TAKEN DURING LIFE

Ample evidence has been presented in the foregoing pages to confirm the claim put forward by Lee that in the estimation of cranial capacity a good formula may be depended upon at least to the same degree as a competent worker by the direct method. We have seen that future work should take into consideration thickness of the cranial walls. This has not been possible hitherto because of our fragmentary knowledge of the rate and relation to the life span of the increase in thickness and of the factors which influence it. It has also been possible to show that there is no real difference between the result of determining capacity by some seed method in the dry skull and that obtained by a direct water determination in the fresh skull with dura intact. The reason for essential agreement between the figures resulting from these two very diverse methods is the fact that during drying the cranium shrinks by about the same volume as the fresh dura occupies after death. If then we are to apply our methods to the living head we have already the fundamental data from which to make the necessary corrections. It will be possible

to obtain a reasonably accurate estimate of cranial capacity in the living provided corrections be made in the linear dimensions for instrumental errors, thickness of soft tissues and shrinkage of the bones in drying.

To take up this problem here would encroach upon ground to be covered in a new research for which the data simply await proper reduction. But though a full presentation must be somewhat delayed there are certain features of the work which can be more properly discussed in this article the tables of which contain the necessary figures. These features are the instrumental errors and the shrinkage of the skull.

To take latter first, we have ascertained that the minimum shrinkage during drying of an average skull totals about 2.3 mm. in length, 2.25 mm. in breadth and 1.8 mm. in auricular height and that a shrinkage of this amount in an average male White skull results in a diminution of capacity by about 50 cc. From this it follows that if a formula upon measurements on the dried skull be employed for calculation of cranial capacity in the living it will give a value about 50 cc. higher than it would if employed upon the dried skull of the same individual. It is therefore well to be quite clear concerning what we mean by cranial capacity. The term applied to the dried skull naturally refers to the entire capacity of the cranium and includes both brain volume and dura volume. It has been shown however that owing to shrinkage the capacity of the cranium, i.e. the brain volume plus the dura volume, is reduced about 50 cc. Now it so happens that 50 cc. is also the approximate volume of the dura. Hence cranial capacity in the dried skull actually approximately represents brain volume alone in the same individual living. From this reasoning it appears that we must accept the figures given by Lee and Pearson for the skull capacities of certain Anatomists, members of the University College Staff and Bedford College students (28 pp. 256–258) as actually giving entire capacity, that is brain volume plus dura volume. To obtain the approximate true brain volume of each of these individuals we must subtract 50 cc. from the figure in the Tables. It is the brain volume alone in the natural skull which corresponds with cranial capacity in the dried skull. For example the average cranial capacity of the thirty-five Anatomists in Table XXV is 1537 cc. But if this average is to be compared strictly with the mean obtained from any collection of dried skulls we must subtract 50 cc. from this figure leaving 1487 cc. The Anatomists may be regarded as a very heterogeneous population in view of the different countries represented by them and it would therefore be more in order to compare their mean

with the means of heterogeneous collections of European crania than to compare them with homogeneous series like, say Ranke's Bavarians or even the Whitechapel crania. As a matter of fact the Bavarians have a mean capacity of 1504 cc. and the Whitechapel crania (first series) of 1477 cc. Our own male Whites of a very low social order show an average capacity of 1391 cc. This contrasts well with the much higher mean of the far more intellectual group.

Having uttered this first caution we glance at the instrumental discrepancy resulting from the use of an instrument upon the living and on the dried skull. It is to be presumed that length and breadth of the head will be taken with either Flower's craniometer or some type of Tasterzirkel; auricular height with some form of head spanner of a combination of Stangenzirkel and Ohrhöhennadel, the optic axis being in the horizontal plane. We have already ascertained the instrumental errors to be expected in these measurements and the results are recorded in Tables VII and IX. The one question which still remains is the instrumental error resulting from the comparison of figures obtained on Flower's craniometer with another set taken by means of an entirely different type of instrument and with the head in a somewhat altered position. My reason for raising this question is the fact that the recorded length in the living is not invariably the greatest horizontal length as defined by the Frankfort agreement. When the skull is set up for measurement it may be assumed that the observer will read greatest length on his instrument when the skull is oriented in the Frankfort plane. This however will not always be the case and frequently we have to accept lengths taken by Flower's craniometer, the skull simply lying upon the table. For these reasons I found it necessary to check observations made on Flower's craniometer in the rough manner just indicated against measurement taken with the greatest care by means of the Cambridge blocks after the skull had been oriented into the Frankfort plane on the Reserve craniostat. The results of this inquiry are to be found in Table IX. From these it is evident that the instrumental error of successive measurements of cranial length taken with Flower's craniometer averages 0.5 mm. For breadth this error averages about 0.3 mm. The figures in columns A. B. were taken with the Cambridge blocks arranged to measure the greatest length wherever found as Miss Fawcett measured her crania. Had the small block giving the glabellar length been substituted no doubt the instrumental difference would have been slightly less than it is. I was seeking the greatest divergence likely to be obtained by the use of figures set down by others.

Between these two modes of determining cranial length there is a mean discrepancy of slightly more than 1.0 mm., Flower's craniometer as a rule giving the smaller measurement. The comparison between greatest length measured strictly in the Frankfort plane but not necessarily in the median sagittal plane and that taken somewhat at random is therefore much closer than one might imagine. I have exaggerated the difference by my method of attack and in a later communication I shall show that the simple instrumental mean error of 0.5 mm. is probably enough to allow for the transference of measurements from the dead to the living or vice-versa. This of course means that the error induced by difference in the instrument and modification of head position may safely be ignored in the calculation of capacity in the living.

For the present we may leave this section, first stating however that although one's possible misgivings on account of instruments and head position may be discarded, yet it is not possible to calculate actual brain volume in the living without seriously considering the shrinkage of the cranial bones during drying. A rather full discussion of corrections for the soft parts may be obtained from a study of the papers by Lee and Pearson (28), Benington and Pearson (5), and Parsons (38).

In concluding I should like to express my indebtedness to Professor A. D. Pitcher of the Mathematics Department of this University for his sympathetic interest in this work. Professor Pitcher is in no way responsible for my interpretation or use of any of the methods employed or for any of the conclusions deduced. I bear the sole responsibility for these, but it has been a great advantage to me to have the advice of Professor Pitcher in my study of mathematical theory and statistical methods in their general aspects.

SUMMARY

The tables of direct measurements from which the formulae in this memoir have been calculated are temporarily withheld from publication on account of space and expense. It is proposed to issue them later in conjunction with other measurements on the same skulls thus avoiding double printing and saving space.

In order to present succinctly the general features and conclusions of the work I am subdividing this summary into sections, each bearing the number of the chapter the substance of which it claims to present. The sections of the summary therefore bear a direct relation to the table of contents at the commencement of the memoir.

PART I. THE DIRECT DETERMINATION OF CRANIAL CAPACITY

1. Direct cubage goes back to the days of Soemmering who made the first estimates with water in 1785. Until 1817 the water method alone was used but after this date it has been rarely employed because of its unsuitability to the measurement of capacity in dried skulls. Sand in 1831, millet in 1837, white pepper seed in 1839 and shot in 1849 were used successively in the determination of capacity. More recently other vegetable grains, glass perles, aluminium shot, rubber bags, pig's bladders, plaster casts and mercury are among the varied collection of accessories used in direct capacity estimates.

By far the best known contribution to this study has been that of Broca, who standardized Morton's shot method after experimenting critically with all other methods then suggested. But all Broca's determinations are too high owing to an error made early in his work and of which he was fully conscious in later days.

Early in the present century, following the origination of the idea in 1897 by Zanke, several workers commenced to make observations upon what they call skull capacity upon the cadaver. Since the dura is still intact this so-called skull capacity is really an approximation of brain volume. It is this particular method of direct measurement which we have followed and upon which our conclusions are based.

2. Each author in bringing forward his method naturally presents it in the best light and the error which he admits must be regarded as the final irreducible minimum of error which, after long practice, he cannot

avoid. The claims for the water estimates on the cadaver are the most reasonable since it is plain that they are based upon the probable error of the ordinary worker who is likely to use the method.

3. Direct methods of capacity determination usually call for such great care in the several steps, or their accuracy is so readily marred by some slight, it may even be, unrecognized modification of technique, that they must all be regarded in the light of a more or less close approximation to the true value, an approximation which, according to various critics, may be 15, 20, 30 or 40 cc. wide of the truth in individual cases. The best results on the dry skull are apparently offered by Hrdlička's method where half of the procedure is mechanical.

4. The direct water method upon the cadaver is, of all direct methods, the most readily applicable and the simplest for capacity determinations in the Anatomical laboratory.

5. The rather elaborate process through which all our skeletal material passes on its way to the Museum calls for determination of capacity and the method by which this determination is carried out is fully given.

6. Capacity estimates upon the fresh cranium with the dura intact are really estimates of brain volume. They may be compared with determinations upon the dry skull only with certain reservations, of which one relates to the dura. The dura volume may be ascertained directly or indirectly. Direct determination by submerging the dura under water after washing out all clot and then eliminating bubbles shows that dura volume varies greatly and that the variation has apparently no relation to age, sex or race. The average dura volume is probably not far from 50 cc.

7. Those who first used the water method claimed for it no more than approximate accuracy to about 50 cc. In this laboratory we have confirmed this statement. It is necessary to distinguish between the probable accuracy of a long practiced observer and that of an equally skilled worker who however has not made a special study of the method and its problems.

8. Objection cannot be raised against the technique of capacity determination which involves measurement upon the bisected skull since checking of this technique against determination upon the same skull used as a natural crâne étalon shows a mean difference of just under five cubic centimeters.

9. After removal of the dura the skull is usually no longer watertight and therefore estimates upon capacity, this time true cranial

capacity, are somewhat less reliable for individual skulls than estimates when the dura is intact although the average over a number of determinations may not be influenced very much.

10. By subtracting the capacity as determined with dura intact from capacity after removal of the dura one may obtain an approximate estimate of the dura volume. The method is not so accurate for individual skulls as the direct determination described in chapter 6, but taken over a series of skulls the approximate average of about 50 cc. is again obtained.

11. By suitably varnishing the interior and exterior of a dried skull and stopping up all holes one may obtain a water estimate of capacity without much difficulty. If this result be compared with the capacity of the same skull fresh (i.e. in the natural condition) after removal of the dura, it will be found that the total capacity has diminished by 50–60 cc. The same result can be obtained by comparing the capacity of the dried skull with that of the fresh skull with dura intact, provided one make proper allowance for dura volume as indicated in chapter 6. Hence in the process of drying a cranium loses 50–60 cc. of its total capacity.

12. It can be shown that capacity determination by the water method is most reliable in the natural skull when the dura is intact. With the skull in this condition a skilled worker's estimates, after some practice will probably be within 1.0 % of the true value.

13. Cranial capacity in the Reserve material is unexpectedly low. The averages are the following: male White 1391 cc.; female White 1232 cc.; male Negro 1350 cc.; female Negro 1221 cc. The sociological factors at work are probably responsible for these figures but there is reason to believe that entirely different sociological influences are affecting the White and the Negro groups. The cranial capacity of our Negroes confirms in a striking manner the forecasts made by Pearson some years ago for the mean Negro capacity.

Part II. THE MATHEMATICAL CALCULATION OF CRANIAL CAPACITY

14. There is no obvious reason against calculation of capacity since all direct methods have been shown to be merely approximations of varying reliability. In view of the possible errors of the various direct methods it is even possible that calculation may result in an approximation as close to the truth as or even closer than direct measurement.

15. In 1836 Parchappe made a bold effort to approximate the value

of capacity by mathematical method. If only one will realize that Parchappe never claimed for his method anything more than standardization of method with an approximation to the truth one must give him great credit for his work. It was not built upon correct statistical theory but neither have been any of the methods currently employed except those introduced by Pearson and his co-workers. Every method except this last group may be considered as useless and obsolete.

16. Pearson's method as developed by Lee for European skulls and by Isserlis for Negro skulls is the only method on a sound mathematical basis and is plainly the method of the future. Anatomists would do well to employ the method much more widely than they have done. Not only would their time be saved but their results would be more reliable and more certainly comparable from one observer to another. My intention in the remainder of this communication is to illustrate the usefulness of this method and to develop it still further upon the Reserve material.

17. The precise details of the technique employed in taking measurements of bones should be accurately presented. The methods employed in the present research are discussed fully.

18. Maceration by Leonhart's live steam method is unusually rapid and precludes the warping during drying so frequently seen in Anatomical laboratories.

19. No statement of anthropometric measurements is really valid unless there is accompanying it a presentation of the possible errors. Anthropological instruments are not standardized; they are expensive and not easy to obtain; there is no influence like a weights and measures law to ensure the elimination of untrustworthy or obsolete instruments. We must therefore have some check upon all possible instrumental errors of a particular observer.

20. On the same principle, when a particular technique is carried out we must have information upon the probable effect of the procedure upon measurements to be taken afterwards. The particular instance in point is bisection of the natural skull on the band-saw.

21. Every new form of apparatus introduced must have, accompanying it as its "character," a statement of its relative and if possible its absolute reliability. In certain measurements, like auricular height, difficult to take, this precaution deserves special emphasis.

22. Sometimes one desires to compare measurements taken by two instruments different in principle and in the adjuncts to measurement.

In such case no comparison of results should be undertaken without the fullest investigation of the instrumental error.

23. Having obtained the linear dimensions of a series of skulls and having assured oneself of their reliability, other sources of error must be thoroughly explored. In the present work there is an obvious source of error in shrinkage of the skull in drying. I am unable to agree with Welcker that the alteration in linear dimensions is negligible. Indeed the minium shrinkage of the three measurements I find in an average skull to be: length 2.3 mm., breadth 2.25 mm., auricular height 1.8 mm. This linear shrinkage corresponds approximately with a change of capacity of about 50 cc. The one set of observations therefore confirms the other.

24. Heterogeneous as are the Reserve White crania, yet they resemble most closely in available material the group of Ranke's Bavarians except that they come from an altogether different social stratum. The most striking difference is in auricular height. The relative steadiness of the auricular height in our male Whites is again in striking contrast to its variability in our male Negroes. This great variability of height in the Negro may be related to the particular contour of his cranium which in many individuals is altogether unlike the condition in the White.

25. and 26. Either a multiple regression formula or one based upon least squares may be used with almost equal confidence for the prediction of cranial capacity of individuals within a local race. It is also possible to transfer these formulae from one local race to another with very little lessening in probable accuracy of result. The result in individual instances is little if any less reliable than the direct determinations of a practised observer in spite of the fact that they take no account of cranial thickness. It has been shown that one may not transfer a formula from one sex to the other with impunity. So also when we have eliminated the thickness of the skull by taking internal measurements or have side-tracked it by a correction for age we shall probably obtain a formula still more reliable, but it must never be imagined that great accuracy is expected; this is impossible in view of the inherent variability of the individual. Failing formulae of our own it would have been perfectly possible to use various of the University College formulae with good result upon our material.

27. I have not had the good fortune of Isserlis in transferring a formula from one human Stock to another. It is admitted that the constants for a least square formula change less from race to race than do the constants for a regression formula. It is also true that I have

worked mainly with regression formulae, but when I did try to apply an inter-racial formula based mainly upon Europeans to the determination of mean capacity of our male Negroes I met with no greater success than with regression formulae. The very fact that the constants of a least square formula vary less from race to race indicates that it is essentially more of an approximation than a multiple regression formula. In this laboratory our critical study of the Negro demands that we explore all methods of discovering and illustrating the fundamental differences in human Stock. Consequently we are more naturally drawn to the regression type of formula than to the least square.

28. Calculation of capacity from linear dimensions taken in the natural state of the skull, that is fresh from the dissecting-room, is liable to give too high a value owing to the fact that the formula has been constructed from measurements upon dried (and shrunken) skulls.

29. To get an instrumental error of 50 cc. which one may take as the possible personal error by the direct method, from a calculation based upon linear dimensions it would be necessary, in the case of an average White male skull, to have an error of about 6.4 mm. in the total of the three linear dimensions. This is unthinkable and it is therefore another reason why mathematical method should displace direct determination.

30. Although it can be shown that for practical purposes the linear measurements of the living head may be transfered to the skull measured with different instruments and according to a totally different principle, yet it is evident that the change in the skull in drying must be suitably corrected in calculation of capacity from measurements in the living. Cranial capacity really comprises brain volume plus dura volume. Now the volume of the dura roughly corresponds with the reduction in volume undergone by cranial capacity during drying. Hence cranial capacity in the dried skull probably comes close to the true brain volume of the same individual living.

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DIMENSIONS OF THE FIRST AND SECOND LOWER MOLARS WITH THEIR BEARING ON THE PILTDOWN JAW AND ON MAN'S PHYLOGENY

ALEŠ HRDLIČKA

THE PILTDOWN MOLARS *vs.* THOSE OF MODERN MAN

Further consideration of the highly interesting teeth of the Piltdown jaw[1] led the writer to examine and take careful measurements on teeth of the principal racial groups of man of to-day, on those of other lower jaws of Early Man, and finally also on those of the anthropoid and other apes.

The lower molars of modern man are seen offhand to be in general relatively short (mesio-distally)and broad (linguo-labially). There are observable individual exceptions, especially for single teeth, but on the whole the maximum breadth of the crown, particularly in the less variable M_1 and M_2, is seen to be not far from its length. Not seldom, in fact, the two dimensions appear equal, and occasionally the breadth may even show in excess of the length. A casual examination of the lower molars of the anthropoid apes gives the impression that these teeth are frequently relatively longer and narrower than in man, though there are also exceptions. All of which makes it highly desirable to have accurate and as far as possible ample measurements on both human and anthropoid molar teeth.

A search through dental and anthropological literature shows that the subject of tooth dimensions is not yet adequately covered. There are various series of data, but none are conclusive. The method of measuring, itself, has not thus far been fully standardized,[2] and even the nomenclature remains unsettled and awkward.[3]

[1]See this Journal, 1922, V, No. 4.

[2]An attempt in this direction is made by R. Martin ("Hdb. d. Anthrop.", 566-'7); but the directions for the length (maximum) are found difficult to follow in practice.

[3]The nomenclature used by the author will be in harmony with the anthropological rather than the unsettled dental terminology. We know the antero-posterior diameter of either the head or the lower jaw as their "length," and the lateral diameter of both as their "breadth," so the terms "length" and "breadth" are applied respectively to the antero-posterior (or mesio-distal) and the lateral (or bucco-lingual) diameters of the molar teeth. It feels unnatural to call the generally longer antero-posterior diameter of these teeth "breadth" and the lateral diameter "thickness," as is usual with most dental writers. Moreover when speaking of the mesio-distal diameter of the lower molars together, all authors will say the *length* of the molars (comp. Selenka, "Menschenaffen," 1 Lief., 1898, 130). Finally, there are authors who use the two terms as they are used here. W. Branco, in "Die menschenähnlichen Zähne aus dem Bohnerz der Schwäbischen Alb (8°, Stuttgart, 1898, p. 30), speaking of the dimensions of molars, defines "Länge" (our Length) as "die Dimension von vorn nach hinten, im Vergleich zu Breite, von aussen nach innen" (also pp. 45, 46). In 1886 Topinard ((*Rev. d'Anthrop.*, 3 sér., I, 406) uses the terms "longueur" and "largeur" exactly as Length and Breadth are used in this paper.

The published records are moreover not always as detailed or precise as desirable, and there is a good deal of duplication. The more important records on the dimensions of the lower first and second molars, the only teeth we are here especially concerned with, are as follows:

In 1874 E. Mühlreiter,[1] (*D. Vierteljahrschr. f. Zahnheilk.*, 122), publishes a table of minimum and maximum dimensions of the teeth of Germans, based on his measurements. These data, which are reproduced in his "Anatomie des menschlichen Gebisses" (3rd ed. Leipz. 1912, 98, 125 *et seq.*), are:

	Lower M_1			Lower M_2		
	Average	Minimun	Maximum	Average	Minimum	Maximum
	mm.	mm.	mm.	mm.	mm.	mm.
Length (antero-post. or mesio-distal diam.)	*11.5*	10.–	12.2	*10.7*	—	—
Breadth (lateral or bucco-lingual diam.)	*10.4*	9.–	11.–	*9.8*	—	—

The number of teeth measured is not given, and no distinction is made as to sex or side.

In 1886, measurements of lower molars in three important racial groups are given by P. Topinard in his "Les caractères simiens de la machoire de la Naulette," (*Rev. d'Anthrop.*, 3 sér., I, 406)[2]

Crania	Lower M_1 Length	Lower M_1 Breadth	Lower M_2 Length	Lower M_2 Breadth
	mm.	mm.	mm.	mm.
15 European	10.5	10.–	9.5	9.3
15 Negro	11.3	10.5	11.5	10.–
15 New Caledonian	11.9	10.4	11.1	10.5

In 1889, G. V. Black in his "Descriptive Anatomy of the Human Teeth" (1st ed., Phila., 1889; 4th ed. 1897, pp. 14-21), gives tables of measurements of all the teeth, which, there being no mention to the contrary, were evidently derived all from white Americans. "The numbers measured of the different varieties differed, but in all denominations they were sufficient to insure reasonable accuracy as to the average size." The dimensions of the 1st and 2nd lower molars are given thus:[3]

[1]Nomenclature used: "Kronenbreite"—"the mesio-distal diameter on the labial side of the tooth;" "Kronentiefe"—the "grösster bukko-lingualer Durchmesser."

[2]No distinction made as to sex or side.

[3]There is no distinction as to sex. The two measurements are defined as follows: "Mesio-distal diameter of crown: this is the extent from mesial to distal in the greatest diameter, or at the points of proximate contact." "Labio- or bucco-lingual diameter." This measurement was taken at the greatest diameter of the crown in the direction named."

	Lower M_1			Lower M_2		
	Average	Minimum	Maximum	Average	Minimum	Maximum
	mm.	mm.	mm.	mm.	mm.	mm.
Length	*11.2*	11.–	12.–	*10.7*	10.–	11.–
Breadth	*10.3*	10.–	11.5	*10.1*	9.5	10.5

In 1895, Max de Terra, in his "Beiträge z. e. Odontographie der Menschenrassen" (8°, Berlin, pp. 22, 71, 85), gave the measurements and B. L. relations of a large number of human lower molars. Unfortunately he gives no means, no indices and no (or but few) individual measurements, which much restricts the use of the data. Also there are no distinctions as to sex or side. The records[1] are:

	No. of Skulls	Lower M_1 Length	Lower M_1 Breadth	Lower M_2 Length	Lower M_2 Breadth
		mm.	mm.	mm.	mm.
Recent Europeans (Whites)	357	10—12	9—11.5	9—11.6	8.5—11.8
Non-Negroid Africans (Egyptians, N. A's)	71	9.7—12	9.2—11.5	8—11.7	8—11
Recent Asiatics (Yellow-Brown)	106	9—12	9.2—11.6	8.8—12	8.2—11
American Indians (misc.)	31	10.4—12.4	9—11.6	9.8—12.4	9.2—11.3
Polynesians	8	10.9—11.6	9.8—11.6	9.9—10.9	9.4—10.8
Negroes	97	9.8—12.8	9—12	9.8—12	9—12
Australians	11	10.8—12.7	10—12.2	11—12.2	10.3—11.9
Melanesians	14	10—12.2	10.2—12	9.8—12.3	9.2—12

In 1899, A. E. Taylor published the following measurements on English teeth ("Variations in the human tooth-form as met with in isolated teeth," *J. Anat. & Physiol.*, XXXIII, 266-272);[2]

	Lower M_1[3]			Lower M_2[4]		
	Average	Minimum	Maximum	Average	Minimum	Maximum
	mm.	mm.	mm.	mm.	mm.	mm.
Length	*10.–*	9.–	11.–	*11.–+*	11.–	12.–
Breadth	*10.–*	9.–	11.–	*11.–*	10.–	12.–

In 1909, E. Hillebrand (*Pester Medizin. Chir. Presse*, XLV, 212) gives measurements of first and second lower molars of skulls from Hungary; 240 of the first molars (no distinction as to sex or side) gave him the average measurement of *10.8* mm. for length and *10.5* mm. for breadth,

[1]Nomenclature: Length—"Breite;" breadth—"Dicke." Also uses however "medio-distale Länge" and "linguo-buccale Länge."

[2]His term for the antero-posterior diameter is "thickness" or "proximo-distal length; and for the lateral or labio-lingual diameter it is "breadth" as in our nomenclature. No distinction is made as to side or sex.

[3]119 extracted teeth; [4]160 extracted teeth.

while 272 second lower molars gave *10.2* mm. for length and *9.8* mm. for breadth.

In 1909 also, the measurements are given of the lower molars of six Australians by H. Klaatsch ("Die neuesten Ergebnisse der Paläontologie des Menschen und ihre Bedeutung für das Abstammungsproblem. *Z. f. Ethnol.*, 1909, XLI, 557-'8), as follows:

	Lower M_1		Lower M_2	
	Length[1]	Breadth	Length	Breadth
	mm.	mm.	mm.	mm.
Australians (right & left)	11.5	12.–	11.8	12.–
	11.2	12.–	12.–	12.–
	10.–	11.–	10.–	11.2
	11.8	11.–	13.2	11.2
	11.–	11.–	12.5	11.2
	12.8	13.–	14.–	13.–

In 1914, in his article "Ueber Zähne frühhistorisches Völker der Schweiz" (*Schweiz. Viertelj. f. Zahnheilk.*, XXIV, 138), F. Schwerz gives measurements of the teeth of a series of V-VIII century Aleman skulls from northern Switzerland:

	Lower M_1	Lower M_2
	Alemanni	
	mm.	mm.
Mean length[2]	11–	10.7
" breadth	10.2	10.4

In 1918, M. Ramström, in a paper on the "Piltdown-Fund" (*Bull. Geol. Inst.* Upsala, XVI, 294-9), gives Max de Terra's previous data on the dimensions and L.B. index of human lower molars, to which he adds the following:[3]

[1]No distinction is made as to sex or side.

[2]Terms used are "breadth" ("Breite") for the antero-posterior; and "thickness" ("Dicke") for the lateral diameter.

[3]No differences are recorded as to sex or side. The measurements are defined thus: "Die Zähne, die ich gemessen habe, steckten alle in ihren Kiefern fest. Bei jedem Zahn wurde mittels Zirkel die Länge der Krone im mesio-distalen Durchmesser, d. h. "Breite" gemessen, vom Zwischenraum zum Zwischenraum der benachbarten aneinandergepressten Zähne; und mittels eines Mikrometers zum Messen der "Dicke" wurde diese Dimension in bucco-lingualer Richtung in der Mitte des Zahnes gemessen. Wo die Zähne in vorderen und hinteren Teile sehr ungleiche Dicke aufwiesen wurden 2 Masse genommen und daraus das Mittel gezogen. Aus den Zahlen der Dicke und Breite ist schliesslich der Index nach folgender Formel berechnet worden:

$$\text{I.}\ \frac{\text{Dicke x 100}}{\text{Breite}}$$

The breadth ("thickness") measurement evidently differed from ours (the maximum) which may account for some of the low indices of Ramström's record.

	Lower M_1		Lower M_2		
	Length	Breadth	Length	Breadth	Index (Both teeth)
	mm.	mm.	mm.	mm.	mm.
Recent Swedes (48 teeth)	10-11.5	10-11.4	10-11	9.5-10.9	*90-110*
Lapps (24 teeth)	9-11	9-10.5	9.4-10.1	8.7-11	*93-104*

Finally, in 1920, Hans Virchow in his work on the Ehringsdorf finds ("Die menschliche Skeletreste aus dem Kämpfeschen Bruch im Travertin von Ehringsdorf bei Weimar." 4°, Jena, 1920, 125), gives a list of measurements and indices of the various human molars. This list which, like all previous records also fails to differentiate sex and side, is:

	Lower M_1			Lower M_2		
	Length[1]	Breadth	Index	Length	Breadth	Index
	mm.	mm.		mm.	mm.	
A Gall	10.5	11.4	*108.6*	10.–	10.3	*103.–*
Early Chinese	10.7	11.3	*105.6*	10.2	10.7	*104.9*
A Chinese	11.7	11.5	*98.3*	11.5	11.–	*95.6*
New Britain (2835)	11.7	11.4	*97.5*	10.5	10.9	*103.8*
" " (2889)	11.–	11.–	*100.–*	10.5	10.9	*103.8*
" " (2863)	10.7	10.7	*100.–*	10.4	9.7	*93.2*
Joruba Negro	11.5	10.4	*90.4*	11.–	11.–	*100.–*
Mulatto	12.6	11.5	*91.3*	12.–	11.5	*95.8*
Early Greek (child)	10.8	9.7	*89.8*	—	—	—

All these previous records leave the question of the absolute as well as the relative dimensions of the highly important first and second lower molars still in some uncertainty; and they throw but little light on the meaning of the narrow teeth of the Piltdown jaw, outside of showing them to be very exceptional. In view of this the writer undertook carefully regulated measurements on larger and more extended series of teeth both human and lower primate, opportunity for which was given by the extensive collections in the Divisions of Physical Anthropology and Mammalogy in the U. S. National Museum.[2]

After preliminary trials, it was found that the best measurements on teeth still in the jaws were the antero-posterior (mesio-distal) diameter from border to border of the tooth (or interdental line to line) *along the middle of the crown*, and the *maximum* lateral (bucco-lingual) diameter, at right angles to the preceding and at right angles also to the height of the tooth (a vertical from midpoint between roots to midpoint of crown). These two measurements, which for reasons explained are called respectively the *length* and *breadth* of the teeth, are very nearly the same as taken by other authors.[3] That of the breadth is, I believe,

[1]Terminology: Antero-post. diam.—"Breite;" lateral diam.—"Dicke."
[2]My thanks are due to Mr. Gerrit S. Miller and his assistant for their generous help in furnishing the anthropoid and lower ape material.
[3]Comp. Martin (R.)—Lehrb. d. Anthrop., 1914, 885.

identical with most, but the length was by some authors measured along the labial or buccal side of the tooth, and in loose teeth is generally the maximum, which in some teeth is liable to differ slightly from that along the median axis of the crown; yet the difference is in no case very material, wherefore the previous records as well as those taken on loose teeth are quite comparable to those to be here added.[1]

Even with an exact definition of the measurements, however, a considerable difficulty was found in securing accuracy of measurements, particularly in small teeth. It is astonishing how hard in many cases it is to get a perfect or repeatedly exactly the same, measurement. Our ordinary instruments do not suffice, and a magnifying glass or lenses are not only very helpful, but at times indispensable. The best results were obtained by taking the length with a needle-point compass, reading the measurements off on a standard scale; and in taking the breadth by an accurate *compas glissière* with narrow flattened branches on one side. Where small differences appear on the two sides, as they often do, there is a need of repeated tests on the two sides. An abstract of the older as well as of the newer data is given by the following table:[2]

MEASUREMENTS OF THE LOWER MOLARS OF MODERN MAN[3]

		Lower M_1			Lower M_2		
People	Number	Length	Breadth	Index	Length	Breadth	Index
Whites:		mm.	mm. *Older Data*		mm.	mm.	
1874 Germans (Mühlreiter)	——	11.5	10.4	*90.4*	10.7	9.8	*91.6*
1886 "European" (Topinard)	15 skulls	10.5	10.-	*95.2*	9.5	9.3	*97.9*
1889 American Whites (Black)	——	11.2	10.3	*92.–*	10.7	10.1	*94.4*
1895 "Europeans" (M. de Terra)	357 skulls	10-12	9-11.5	—	9-11.6	8.5-11.8	—
Northern Africans (non-negroid) do	71 skulls	9.7-12	9.2-11.5	—	8-11.7	8-11	—
1899 English (Taylor)	M_1-119 M_2-160	10.–	10.–	*100.–*	11.5	11.–	abt *95.6*
1909 Hungarians (Hillebrand)	M_1-240 M_2-272	10.8	10.5	*97.2*	10.2	9.8	*96.1*

[1]Even under strict regulations and with the best instruments measurements of teeth are not easy and with the greatest care differences up to 1 mm. by different and even the same workers are frequent. The method here described seems to offer about the best chances for approximate accuracy.

[2]The details which show many additional, but in this place irrelevant, points of interest, will be published later.

[3]Most of the indices and the general averages calculated by author of present paper.

MEASUREMENTS OF THE LOWER MOLARS OF MODERN MAN

People	Number	Lower M_1 Length	Lower M_1 Breadth	Lower M_1 Index	Lower M_2 Length	Lower M_2 Breadth	Lower M_2 Index
		mm.	mm.		mm.	mm.	
1914 Alemans (Schwerz)	—	11.–	10.2	*92.7*	10.7	10.4	*97.2*
1918 Swedes (Ramström)	48 teeth	10-11.5	10-11.4		10-11	9.5-10.9	*90-110* (both teeth)
			New Data				
1923 U. S. Whites (Hrdlička)	160 teeth 40 skulls	10.60	10.40	*98.–*	10.36	10.04	*96.9*
Egyptians (XII Dyn.) (Hrdlička)	120 teeth 30 skulls	10.48	10.27	*98.–*	10.39	10.01	*96.3*
Yellow browns			Older Data				
1895 "Recent Asiatics" (M. de Terra)	106 skulls	9-12	9.2-11.6		8.8-12	8.2-11	
American Indians do)	31 skulls	10.4-12.4	9-11.6		9.8-12.4	9.2-11.3	
Polynesians (do)	8 skulls	10.9-11.6	9.8-11.6	—	9.9-10.9	9.4-10.8	
1918 Lapps (Ramström)	24 teeth	9-11	9-10.5	—	9.4-10.1	8.7-11	*93-104* (both teeth)
1920 Chinese (H. Virchow)	2 skulls	11.2	11.4	*101.8*	10.8	10.8	*100.–*
			New Data				
1923 Indians (U. S.) (Hrdlička)	400 teeth 100 skulls	11.07	10.94	*98.9*	10.70	10.60	*99.–*
Eskimo (do.)	160 teeth 40 skulls	11.19	10.93	*97.8*	10.94	10.65	*97.3*
Blacks			Older Data				
1886 Negro (Topinard)	15 skulls	11.3	10.5	*92.9*	11.5	10.–	*87.–*
1895 Negroes (M. de Terra	97 "	9.8-12.8	9-12	—	9.8-12	9-12	—
1886 Caledonians (Topinard)	15 "	11.9	10.4	*87.4*	11.1	10.5	*94.6*
1895 Melanesians (M. de Terra)	14 "	10-12.2	10.2-12	—	9.8-12.3	9.2-12	—
1920 New Britain (H. Virchow)	3 "	11.1	11.–	*99.1*	10.5	10.17	*100.3*
1895 Australians (M. de Terra)	11 "	10.8-12.7	10-12.2	—	11-12.2	10.3-11.9	—
1909 Australians (Klaatsch)	6 "	11.4	11.7	*102.5*	12.2	11.8	*96.1*
			New	Data			
1923 Negro, African & American (Hrdlička)	80 teeth 20 skulls	11.05	10.69	*96.7*	10.71	10.63	*99.3*
Melanesians (do)	80 teeth 20 skulls	11.42	10.96	*96.–*	10.69	10.55	*98.7*

The above records constitute together a respectable body of data which even though there had been slight differences in the method of measuring by the different authors, give us a fairly good picture of at least the main conditions. They may be assumed to give us fairly definitely the limits of size of the two lower molars and their average crown index.

The absolute dimensions are seen to range, for M_1, length 9 to 12.8, breadth 9 to 12.2; and for M_2, length 8.8 to 12.4, breadth 8.2 to 12 mm.; while the mean index in the different groups extends, for M_1, from 87.4 to 102.5, and for M_2 from 87 to 110.

On the basis of these records, and to facilitate our dealing with the crown index of the lower molars, the latter may be subdivided into three categories, which are:

Breadth-length index $\frac{(B \times 100)}{L}$ below and to 89.9—*dolichodont;*

Index 90-100 . . . . *mesodont;*
Index above 100 . . . . *brachydont.*

Teeth of index below 80 may properly be called hyperdolicho—, teeth above 110, hyperbrachydont.

Under this classification, it may be observed, nearly 80 percent of the group indices in modern man fall in the class of mesodont, 16 per cent into that of brachydont and only 5 per cent into that of dolichodont teeth.

The Piltdown molars, with the dimensions of M_1, Length—13, Breadth—11, Index—*84.6*, and M_2, Length—13, Breadth—11.3, Index *86.9*, are longer than any of the modern teeth here recorded, and their index is lower than that of any of the groups whose teeth have been measured. They are, therefore, in comparison with the teeth of modern man, very exceptional. Nevertheless they connect with these. In the writer's article on "The Piltdown Jaw" (*A. J. P. A.*, '22, V, 345) it was shown that rarely modern individual human lower molars may even in length equal or come very close to those of Piltdown; and our own measurements have shown that there are individual lower molars of man to-day that equal the Piltdown teeth and may even fall below them in the crown index.[1] But such cases are very uncommon. The facts may be summarized by the statement that in both their absolute and relative length the Piltdown molars, though connecting with the teeth of present man, do so only at a great distance from his average conditions.

[1]Several lower molars of white American women gave the index of *86.4*, while the right second lower molar of one gave that of *81.8*.

DIMENSIONS OF THE FIRST AND SECOND LO

EARLY MAN

The next logical step in the study of the positon of the Piltdown molars is to contrast them with those of other remains of Early Man.

A number of original (as well as of copied) data on the dimensions of the lower molars in ancient man are found in literature, but the record is not complete. Moreover, authors who in some instances have measured the same teeth, do not give exactly the same results (compare Klaatsch's and Hans Virchow's measurements of the teeth of the Mousterian youth), and there are in various cases differences between the published records and measurements on casts of the same specimens. There is a need of remeasuring by one person and the best instruments of all the originals. The data to be given below are the records of the principal authors, supplemented, where such records are wanting, by the present writer's measurements on either the originals or first-hand casts.[1] The data are given chronologically, and the records are supplemented by a summary arranged on the basis of the tooth index, which is steadily growing in interest as more observations are being gathered: they are as follows:

In 1887, Julien Fraipont and Max Lobest in their memoir on "La race humaine de Néanderthal ou de Canstadt en Belgique" (*Arch. de Biol.*, VII, 637-643), give measurements of the teeth of the two Spy crania and lower jaws. The dimensions of the 1st and 2nd lower molars are given as follows:[2]

	Lower M_1		Lower M_2	
	Length	Breadth	Length	Breadth
	mm.	mm.	mm.	mm.
Spy No. 1	10.–	10.5	10.–	10.–
Spy No. 2	11.– to 11.5	11.– to 11.5	11.–	11.–

In 1906, in his final report on "Der diluviale Mensch von Krapina" (4°, Wiesbad., 202-3), Gorjanovič-Kramberger gives revised measurements of the Krapina teeth.[3] The dimensions of the first and second lower molars are:

[1]The measurements of the teeth of the Mauer jaw, recorded in the writer's article on the Mauer Jaw (this *Journal*, 1922, V, 345), taken on a cast, are evidently at fault; the measurements given here will be those of Schoetensack, taken on the original.

[2]Nomenclature: Length, "largeur;" breadth, "épaisseur."

[3]Earlier measurements may be found in his "Der paläolitische Mensch" etc. *Mitt. Anthrop. Gess. Wien*, 1901, XXXI, 192-3.

	Lower M_1 Length[1]	Breadth[1]	Lower M_2 Length	Breadth
Isolated Teeth				
Teeth showing no wear	13.4	12.4	12.1	11.--
(4 teeth not pairs)	12.4	10.8	10.7	10.2
Teeth showing some wear	11.2 to	10.5 to	11.4 to	10.6 to
(10 first, 7 second)	13.8	12.4	12.5	11.4
Teeth in Jaws				
"D"	11.--	10.6	——	——
"E"	12.9	12.1	12.8	11.5
"G"	12.3	11.4	12.6	11.4
"H"	r.11.3	10.9	12.--	11.6
	l.11.5	11.--	11.5	11.5
"I"	11.4	11.1	12.--	11.8

The next record of molar measurements is presented by Otto Schoetensack in his work on the Mauer jaw ("Der Unterkiefer des Homo Heidelbergensis", 4°, Leipz., 1908, 56-58). He also is one of the few authors who give the percental breadth-length relation of the crown of the molars. His data include most of the measurements of Branco. Those on teeth of Early Man are as follows:

	Lower M_1 Length[2] (diam. anter.post)	Breadth (diam.later max.)	Index	Lower M_2 Length (diam. anter.post.)	Breadth (diam.later max.)	Index
	mm.	mm.		mm.	mm.	
H. Heidelberg.	11.6	11.2	*96.6*	12.7	12.–	*94.5*
Ochos (Moravia)	r. 11.5	11.–	*95.7*	12.–	12.2	*101.6*
	l. 12.–	11.2	*93.3*	12.–	11.5	*95.8*

In 1909 and 1910, H. Klaatsch gives measurements of the lower molars (as well as other teeth) of the Aurignacian, the Mousterian and the Galley Hill skulls ("Homo Aurignacensis," *Praehist. Zeitschr.*, 1910, 305-'6; also *Z. f. Ethnol.*, 1909, XLI, 557-'8):

	Lower M_1 Right Length	Breadth	Left Length	Breadth	Lower M_2 Right Length	Breadth	Left Length	Breadth
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
H. *Aurignacensis*	12.–	12.–	12.–	11.–	12.–	11.5	11.5	11.–
H. *Mousteriensis*	12.5	11.8	12.4	11.5	12.5	11.6	12.5	11.6
Galley Hill	11.–	11.1	——	——	10.3	11.3	——	——

P. Adloff, in 1910 ("Neue Studien über das Gebiss der diluvialen und rezenten Menschenrassen," *D. Monatsschr. f. Zahnh.*, XXVIII, 134-159), besides giving older measurements of teeth of Early Man (Spy, Heidelberg, H. Mouster.) adds a few of his own taken on the teeth of several

[1] "Kronenbreite" or mesio-distal diameter; "Kronendicke" or labio-lingual diameter. But on previous pages the molars are referred to as "lang" and "breit," as in our nomenclature.

[2] Terminology: "Kronenbreite" (mesio-distal diameter); "Kronendicke" (labio-lingual diameter). No distinction as to sex.

of the lower jaws from Predmost. He found the length (mesio-distal diameter) of M_1 to range from 10,— to 12.5 mm., the breadth (lateral or labio-lingual diam.) from 11.— to 11.25 mm.; while the corresponding dimensions of M_2 were respectively 9.5 to 11.5 and 9.75 to 11.5 mm.

In 1917, Dr. A. Woodward, in his "Fourth Note on the Piltdown Gravel" (*Q. Jour. Geol. Soc.*, LXXIII), gives his corrected measurements of the Piltdown teeth as: M_1, length 12.5, breadth 11.—; and M_2, length 13.—, and breadth 11.5 mm. Measurements of "width" (our breadth) of the two right molars taken by Pycraft are: M_1, 11.—; for M_2, 11.5 mm. (Miller, G. S., The Piltdown Jaw, *Am. J. Phys. Anthrop.*, 1918, I, 34).

In 1920, Hans Virchow (*op. cit.*) gives what are evidently his own measurements on the lower molars of the Mousterian youth and the Ehringsdorf jaws:

	Lower M_1			Lower M_2		
	Length[1]	Breadth[2]	Index	Length	Breadth	Index
	mm.	mm.		mm.	mm.	
Le Moustier youth	12.–	11.5	*95.8*	12.7	11.5	*90.5*
Ehringsdorf adult	11.7	10.9	*93.2*	13.–	11.5	*95.8*
" juv.	12.–	10.5	*87.5*	12.9	10.8	*83.7*
The Taubach molar	(11.7)	(10.4)	(*88.9*)	—--	—	—

It will be interesting to summarize the above records on the basis of the crown index: (see next page)

The position of the Piltdown teeth in relation to the corresponding teeth of all the rest of the remains of Early Man—where such teeth are preserved—is quite as striking as it was in the case of modern races. With the exception of one or two of the Krapina first molars the Piltdown teeth exceed all the other early lower molars in length, and with one exception, that of the juvenile Ehringsdorf second molar, they present the lowest breadth-length index. The lower molars of Early Man are seen to be, much as in present man, essentially meso- to brachydont, and only very exceptionally dolichodont. It appears however that in general the more recent the teeth, more particularly the first molars, the shorter they are, and *vice-versa*. The length of the tooth on the whole appears to diminish with progress in time, while the breadth remains about equal. In breadth the Piltdown teeth are ordinary human, early and recent, but they are longer than either, which points to a very early age of the jaw—indication wholly in harmony with the main other features of the specimen. The wholly normal and harmonious character of the three molars practically excludes the assumption that we may be confronted here with a mere individual peculiarity.

[1]"Labio-lingual" diameter.
[2]"Medio-distal" diameter.

THE LOWER MOLARS OF EARLY MAN
Arranged on the Basis of the Crown Index

	Lower M_1			Lower M_2		
	Right & Left Length	Breadth	Index	Right & Left Length	Breadth	Index
	mm.	mm.		mm.	mm.	
Obercassel, Female (Bonnet)	r. 10.–	11.–	*110.–*	10.5	11.–	*104.8*
	l. 10.–	11.–	*110.–*	10.–	10.5	*105.–*
" Male (Bonnet)	r. 11.5	12.–	*104.3*	12.–	12.–	*100.–*
	l. 11.–	11.5	*104.5*	12.–	12.–	*100.–*
La Quina, (Hrdlička, from cast)	r. 11.–	11.5	*104.5*	12.5	12.–	*96.–*
	l. 10.5	11.5	*109.5*	12.5	12.–	*96.–*
H. Aurignacensis, (Hrdlička, from cast)	r. 11.–	11.5	*104.5*	11.5	11.2	*97.4*
	l. 11.–	11.8	*107.3*	11.5	11.5	*100.–*
Spy No. 1 (Fraipont)	10.–	10.5	*105.–*	10.–	10.–	*100.–*
" No. 2 "	r. 11.–	11.–	*100.–*	11.–	11.–	*100.–*
	l. 11.5	11.5	*100.–*	—	—	—
Jersey Teeth (Hrdlička, from cast)	r. —	—	—	12.–	12.–	*100.–*
	l. –	—	—	12.–	12.–	*100.–*
Předmost (Adloff)	10.–to 12.5	11.–to 11.25	near *100.–*	9.5 to 11.5	9.75 to 11.5	near *100.–*
Ochoz, Moravia (Schoetensack)	r. 11.5	11.–	*95.7*	12.–	12.2	*101.6*
	l. 12.–	11.2	*93.3*	12.–	11.5	*95.8*
Šipka (Hrdlička, from cast)	12.3	11.7	*95.1*	12.–	11.7	*97.5*
Ehringsdorf, adult (H. Virchow)	11.7	10.9	*93.2*	13.–	11.5	*95.8*
H. Heidelbergensis (Schoetensack)	r. 11.6	11.2	*96.6*	12.7	12.–	*94.5*
H. Mousteriensis[1] (Klaatsch)	r. 12.5	11.8	*94.4*	12.5	11.6.	*92.8*
	l. 12.4	11.5	*92.7*	12.5	11.6	*92.8*
Krapina (Gorjanovič-Kramberger)	*8 M_1* 12.02	11.29	*93.9*	*7 M_2* 11.96	11.29	*94.4*
	Extreme *18 M_1* (11.– to 13.8)	(10.5 to 12.4)	(*87.1* to *98.2*)	*14 M_2* (10.7 to 12.6)	(10.6 to 11.6)	(89.8–*100.–*)
Molar of Taubach (H. Virchow	(11.7)	(10.4)	(88.9)			
Ehringsdorf, juv. (H. Virchow)	12.–	10.5	*87.5*	12.9	10.8	*83.7*
Piltdown (Hrdlička)	r. 13.–	11.–	*84.6*	13.–	11.3	*86.9*
	l. 13.–	11.–	*84.6*	—	—	—

APES

In view of the above and of what has been written about the apparent ape-like characteristics of the jaw, it becomes of great interest to compare more thoroughly than has been possible heretofore, the Piltdown molars with corresponding teeth of the anthropoid apes. Thanks to Mr. Gerrit S. Miller, I was able to utilize the rich materials from the Division of Mammals of the U. S. National Museum. The previous records and the writer's results are given in the following pages and table.

[1]H. Virchow (Die menschl. Skeletreste v. Ehringsdorf, p. 125) gives: lower M_1—12., 11.5, *95.8*; lower M_2—12.7, 11.5, *90.5*. There is evidently an error in the length of the M_1.

The first to give valuable measurements of the lower molars of the anthropoid apes is P. Topinard (*Rev. d'Anthrop.*, 1886, 3 sér., I, 405). The teeth of 11 gorillas and 4 orangs gave him the following dimensions:[1]

	Lower M_1		Lower M_2	
	Length	Breadth	Length	Breadth
	mm.	mm.	mm.	mm.
Gorillas (11)	14.9	12.7	16.4	14.3
Orangs (4)	13.4	12.–	14.1	12.4

E. Mühlreiter in 1892, in his "Ein Beitrag zur Grössen-Bestimmung der Zähne der anthropoiden Affen" (*D. Vierteljahrschr. f. Zahnh.*, X, 323-336), gives incomplete measurements of a series of anthropoid teeth of which the following may be extracted:

			Lower M_1		Lower M_2	
	Number	Sex	Length	Breadth	Length	Breadth
			mm.	mm.	mm.	mm.
Gorilla eng.[2]	1	Male	16.–	——	18.4	16.–
" "	1	"	15.2	14.–	16.7	15.–
" "	1	Female	15.–	——	16.5	16.–
" "	1	"	14.5	12.5	16.5	14.5
Chimpanzees	1	Male	11.7	——	11.7	11.5
"	1	"	11.6	11.–	——	——

In 1893 Batujeff, in an article "On the general morphological characteristics of the crowns of human teeth and other vertebrates" (*Publ. Milit.-Med. Acad.*, St. Petersb., I, Pt. 1, 26-100. In Russian), gives (quoted after M. de Terra) the following measurements for the lower molars of the anthropoid apes:

	Lower M_1		Lower M_2	
	Length	Breadth	Length	Breadth
	mm.	mm.	mm.	mm.
Gorillas	14-16	11-13	14.5-18.5	12-16
Chimpanzees	9-10	8-9	9.5-10.5	8-10
Orangs	11-14.5	9-13	12-15	10-15
Gibbons	5-8.5	4.5-5	5-9	4.5-5.5

In 1895, in his "Ueber einen menschlichen Molar aus dem Diluvium von Taubach bei Weimar" (*Z. f. Ethnol.*, 1895, 573-'7), A. Nehring gives the measurements of 2 gorillas, 3 chimpanzees and 4 orangs:

[1]No separation as to side or sex.

[2]Measurements of another male *G. eng.* are given as: M_1, L—15.2, B—15; M_2, L—17.2, B—17. These figures are evidently erroneous—no gorilla has ever been known with teeth practically as broad as long, and with the breadth of one of the molars reaching 17mm.

The author also gives the following plainly erroneous data for the dimensions of a male orang: M_1, L—18; M_2, L—18.2, B—12.5; no known orang tooth has reached such a length or anywhere near such a low index.

			Lower M_1		Lower M_2	
	Number	Sex	Length	Breadth	Length	Breadth
			mm.	mm.	mm.	mm.
Gorilla	1	Male	15.–	12.–	17.–	15.–
"	1	Female	14.8	12.–	16.2	15.–
Chimpanzee	1	Male	10.3	9.8	12.–	11.–
"	1	Female	10.–	9.4	10.5	10.–
"	1	Female	10.7	9.7	10.9	10.–
Orangs	1	Male	13.8	12.3	15.–	13.–
"	1	"	13.7	12.2	13.7	13.–
"	1	Female	12.7	11.–	12.7	11.6
"	1	"	13.4	12.–	13.6	12.5

W. Branco, in 1898, in his report on the fossil teeth from the Schwabian Alb (8°, Stuttgart, Pt. I, 43), gives a series of measurements of the teeth of various anthropoid apes:

	Lower M_1			Lower M_2		
	Length mm.	Breadth mm.	Index	Length mm.	Breadth mm.	Index
Chimpanzee	11.4	10.3	*90.3*	12.–	11.2	*93.3*
Orang	12.8	11.8	*92.2*	15.5	13.9	*90.–*
	14.9	13.–	*87.2*	——	——	——
Gorilla	15.3	13.5	*88.2*	16.–	14.6	*91.3*
Hylobates leuc.	6.–	5.–	*83.3*	6.7	5.6	*83.6*
	6.–	5.–	*83.3*	6.6	6.–	*90.9*
Hylobates synd.	8.–	5.8	*72.5*	8.5	7.–	*82.3*

In 1905, Max de Terra, in his "Odontographie des Menschenrassen" (8°, Parchimi, M., 256-269), adds the measurements of the teeth of 4 gorillas, 5 orangs, 3 chimpanzees, and 3 gibbons:[1]

			Lower M_1		Lower M_2	
	No.	Sex	Length	Breadth	Length	Breadth
			mm.	mm.	mm.	mm.
Gorilla gina	1	?	15.–	12.–	15.2	12.2
" "	1	Male	17.–	12.8	18.–	15.–
" "	1	Female	14.5	11.5	16.–	13.6
" "	1	"	15.3	12.2	17.–	14.–
Orangs	3	Male	13-14.9	11.7-13.6	14.5-16	13.2-14.8
"	5	Female	11.5-12.7	10-11.3	12.2-13.8	10.8-11.7
"	1	?	12.7	10.8	12.7	11.3
"	1	?	14.8	12.8	15.–	13.5
" juv.	7	?	13–13.5	11.5-11.8	——	——
Chimpanzees	2	Male	10.4–12	9.2-11	10.5-12.5	9.6-11.5
" juv.	1	Female				
" "	7	"	10.8-11	8.9-9.8	——	——
Hylobates lar.	2		5.2-5.3	4.7	5.5-5.7	5.–
" syndact.	1	Male	8.–	6.2–	9.–	7.2
" "	1	?	7.5	5.9	7.9	6.4

In 1918 M. Ramström, in his study on early and modern human teeth (*op. cit.*), gives also a series of data on chimpanzees. These data show

[1]The actual number of specimens whose teeth were measured, as in the case of other authors, is greater, but the lower molars were not always present.

on one hand some unparalleled, for chimpanzees, low indices; and on the other some unparalleled, for chimpanzees, large teeth. These facts would seem to suggest that the series of teeth may not have been wholly that of chimpanzees, but that it may possibly have included some of the smaller gorillas. If not then there are in that series some wholly exceptional chimpanzees that ought to be made known. The data, which for the present can hardly be used for comparisons, are as follows:

	Lower M_1		Lower M_2		Both Molars
	Length	Breadth	Length	Breadth	Index
	mm.	mm.	mm.	mm.	mm.
Chimpanzees (64 teeth)	9.5-14.2	7.5-11.3	9.5-15.5	8-13	74.6 (?) 90

To the above Hans Virchow in 1920, in his report on the human remains of Ehringsdorf (*o. c.*), adds the following:

	Lower M_1			Lower M_2		
	Length	Breadth	Index	Length	Breadth	Index
	mm.	mm.		mm.	mm.	
Orang, Male	13.–	12.2	93.9	14.2	13.7	96.5
" ?	12.–	10.5	87.5	13.–	11.4	87.7
" ?	12.9	11.5	89.1	14.8	12.5	84.4
Chimpanzee, male	10.5	9.5	90.5	11.5	10.5	91.3
" female	10.8	9.7	89.9	11.6	10.7	92.2
Gorilla male	16.4	14.–	85.4	18.–	15.–	83.3
" juv.	16.–	14.1	88.1	—	—	—
Hylobates syndact., male	8.3	6.2	74.7	9.4	6.8	72.3
" " female	7.8	6.7	85.9	8.5	7.3	85.9
Macacus fusc.	8.1	6.4	79.–	9.6	7.7	80.2

The preceding data, supplemented by an abstract of those of the writer, secured on the excellent and well identified material in the U. S. National Musuem, may be, as far as practicable, summarized in the table following. (next page)

This brief table is full of interest. Various facts appear clearly for the first time, but the main is that with the Piltdown teeth there is no direct relation. They do not belong to this group. They are larger and especially longer and have a lower index, than any in the chimpanzees; They are relatively longer than those of the orangs, relatively broader than those of most of the gibbons; and the second molar differs markedly from all those of these apes in being of very nearly the same size with the first, which is a common human but exceedingly rare ape character. The nearest in relative proportions to the Piltdown molars are the teeth of the gorillas, but the relation goes no further. Notwithstanding their peculiarity the Piltdown teeth are plainly (especially when besides the measurements all their other characters are taken into consideration) much nearer the early human than they are to those of any existing

SUMMARY OF DIMENSIONS OF LOWER MOLARS OF PRESENT-DAY ANTHROPOID APES

	Tooth	No. of Jaws	Sex	Length Average[1]	Length Range	Breadth Average	Breadth Range	Index Average	Index Range
				mm.	mm.	mm.	mm.		
					Older Data				
Chimpanzees	M_1	17+	Both[2]	10.8	9-12	9.9	8-11	*92.–*	89.4-95.1
	M_2	8+	"	11.5	9.5-12.5	10.7	8-11.5	*93.–*	90-98.3
					New Data				
	M_1	10	Male	10.63	10-11.3	9.80	9-10.5	*92.2*	86.4-100
	"	10	Fem.	10.30	10-11	9.60	9-10.5	*93.1*	90-100
	M_2	10	Male	10.90	10-11.5	10.37	9-11.5	*95.–*	90-100
	"	10	Fem.	10.55	9-11.5	9.97	9-11	*94.5*	87-100
					Older Data				
Gorillas	M_1	23+	Both	15.3	14-18	12-18	11-14.1	*83.5*	75.2-92.1
	M_2	23+	"	16.6	14.5-18.5	14.6	12-16	*88.–*	80.2-96.9
					New Data				
	M_1	20	Male	15.32	13-18	13.46	12-16	*88.9*	79.4-96.8
	"	2	Fem.	14.25	14-14.5	11.45	11.2-11.7	*80.4*	77.2-83.6
	M_2	20	Male	17.27	14.5-20	15.15	13.2-18	87.7	79.4-94.3
	"	2	Fem.	16.12	15.5-16.5	13.10	13-13.2	*81.2*	78.8-85.2
Orangs					*Older Data*				
	M_1	26+	Both	13.35	11-14.9	11.85	9-13.6	*88.7*	85.1-93.9
	M_2	22+	"	14.05	12-16	12.6	10-15	*89.9*	84.4-96.5
					New Data				
	M_1	20	Male	13.65	12-16	12.74	12-15	*93.1*	85.7-104
	"	20	Fem	12.48	11-13.5	11.35	10-12.5	*90.9*	83.3-100
	M_2	20	Male	14.39	13-16	13.74	13-17	*95.5*	86.7-106.2
	"	20	Fem.	12.69	11-14	12.15	11-13	*95.9*	88-106.6
Gibbons					*Older Data*				
H.syndact.	M_1	5	Both	7.92	7.5-8.3	6.16	5.8-6.7	*77.9*	72.5-85.9
	M_2	4	"	8.66	7.9-9.4	6.94	6.4-7.3	*80.3*	72.3-85.9
Symphalangus[3] synd.					*New Data*				
	M_1	4	Male	8.55	8.2-9	6.63	6.5-6.8	*77.6*	72.2-82.9
	M_2	4	Fem.	7.62	7-8.5	6.18	5.5-6.7	*81.1*	76.5-86.7
	M_1	4	Male	8.48	8.7-9.2	7.26	7-7.5	*80.8*	77.8-83.3
	M_2	4	Fem.	8.40	7.3-9.3	6.80	6.5-7.2	*81.–*	76.5-89
					Older Data				
Hylobates var. sp.	M_1	4	Both	5.6	5.2-6	4.85	4.7-5	*86.5*	83.3-89.5
	M_2	4	"	6.1	5.5-6.65	5.4	5-5.8	*88.5*	87.2-89.3
					New Data				
	M_1	10	Male	6.01	5.5-6.5	4.95	4.7-5.2	*82.4*	76.9-86.2
	"	4	Fem.	5.74	5.2-6.5	5.05	4.8-5.5	*88.–*	76.9-92.3
	M_2	10	Male	6.42	6-7	5.59	52.6	*87.–*	83.9-93.3
	"	4	Fem.	6.20	5.5-7	5.44	4.8-6	*87.7*	82.9-94.8

anthropoid apes. They stand apart from the latter and connect, even though at the base of the scale, with the former.

[1]The averages of the older data are only approximate, derived as closely as possible from the total of the records.
[2]In the older records males predominate; though sex is not always given nor, judging from the size of the teeth, always reliably determined.
[3]Doubtless the same genus as reported in older records under the name of *H. synd.*

The data on the anthropoid apes themselves show a number of features of some importance which may be brought out in this connection.

The first thing that strikes one's attention are the remarkable differences not merely in the actual size of the teeth in the different species, but also in the form of the crown. The indices of the latter range, it is seen, from hyperdolichodont in the Symphalangus, to dolichodont in the Hylobates and Gorilla and to mesodont in the Chimpanzees and Orangs. The most unexpected difference in this respect is that between the teeth of the Symphalangus and the Hylobates, two genera of one family—the Gibbons. The difference lies principally in the greater length of the teeth of the Symphalangus: the Symphalangus is a larger ape and has larger teeth than the Hylobates, which may have some connection with the difference of tooth form.

The differences next in importance are those between the two sexes. It is seen that the molars of the females are invariably, on the average, perceptibly smaller than those of the males. But the teeth of the females differ also from those of the males in their relative dimensions, as shown by the tooth index. These latter differences are, however, not the same in all species. In the Gorillas and Orangs the male teeth, particularly the first molars are relatively stouter *i. e.* broader than those of the female; in the Chimpanzees a slight difference in the same direction is observed in the second molars, but the first molars appear to be relatively slightly shorter in the females, giving them a slightly higher crown index; in both genera of the Gibbons, finally, the first lower molar is perceptibly shorter in the females, giving these a higher crown index, while the second molars are about the same in the two sexes.

Regardless of sex, the average index of the first molars in all the apes here shown, except perhaps in the female Hylobates, differs from that of the index of the second molar, the latter being slightly to moderately higher. On comparison of the respective lengths and breadths of the two teeth it is found that the higher index of the second molar is generally due to its relatively greater thickness.

The third fact to be noted is one which has already been partly mentioned, namely the greater average dimensions in all the species of anthropoid apes of the second than the first lower molar. The percental relation of the length and breadth of the second to the first molar in the different groups, M_1 being taken as 100, is as follows: Chimpanzees, males 104.1; females, 103.6; Gorillas, males 112.6; females 113.7; Orangs, males 106.6; females 104.2; Symphalangus synd., males 106.9; females 110.1; Hylobates, males 109.6; females 107.9. In the Piltdown

teeth this relation is just a trifle over 100, in the human lower molars it varies from slightly above 100 in a few individuals, to below 100 in a great majority.

For purposes of possible indications, the author also made measurements on a dozen representative species of Old World monkeys as well as on 10 American forms.

The Old World apes show a crown index ranging from decidedly hyperdolicho- to mesodont in the first molars and slightly brachydont in the second (two species). Some of the species therefore connect in this respect with the anthropoid apes.

LOWER MOLARS IN OLD WORLD MONKEYS

	Right						Left					
	M_1 L'gth	M_1 Bd'th	M_1 Ind.	M_2 L'gth	M_2 B'dth	M_2 Ind.	M_1 L'gth	M_1 B'dth	M_1 Ind.	M_2 L'gth	M_2 B'dth	M_2 Ind.
	mm	mm		mm	mm		mm	mm		mm	mm	
Colobus caudatus, 182,366 Male	7.–	6.–	*85.7*	7.2	6.5	*90.3*	7.–	6.–	*85.7*	7.2	6.5	*90.3*
Magus 199,905 Male	7.2	6.–	*83.3*	8.–	7.–	*87.5*	7.2	6.–	*83.3*	8.2	7.2	*85.4*
Lasopyga pyger. 162,896 Male	5.3	4.5	*84.9*	6.7	5.3	*79.1*	5.4	4.7	*87.–*	6.7	5.5	*82.1*
Macaca syrichta 144,681 Female	6.5	5.5	*84.6*	7.5	6.–	*80.–*	6.5	5.6	*86.2*	7.5	6.2	*82.7*
Cynopithecus niger 144,549 Male	6.–	5.–	*83.3*	7.–	5.5	*78.6*	6.–	5.–	*83.3*	7.–	5.5	*78.6*
Simia sylvanus 196,984 ?	7.8	6.–	*76.9*	9.2	7.–	*76.1*	7.8	6.–	*76,9*	9.2	7.–	*76.1*
Cercocebus albigena 164,578 Female	6.5	5.–	*76.9*	6.5	6.–	*92.3*	6.5	5.–	*76.9*	6.5	6.–	*92.3*
Nasalis 196,789 Male	7.2	5.5	*76.4*	9.1	6.5	*71.4*	7.2	5.7	*79.1*	9.1	6.6	*72.5*
Papio anubis 182,146 Male	10.5	8.–	*76.2*	12.7	10.–	*78.7*	10.5	8.–	*76.2*	12.5	10.–	*80.–*
Simias concolor 121,663 Male	6.5	4.9	*75.4*	6.5	5.2	*80.–*	6.5	4.9	*75.4*	6.5	5.2	*80.–*
Erythrocebus whitei 164,684 Male	7.–	5.2	*74.3*	8.5	6.2	*72.9*	7.–	5.2	*74.3*	8.5	6.2	*72.9*
Theropithecus obscurus 142,505 Female	11.–	7.5	*68.2*	13.5	9.–	*66.7*	11.–	7.5	*68.2*	13.5	9.–	*66.7*

In all these monkeys as in all the higher apes the second molars are larger than the first. In five species the second molars are relatively broader (or shorter) than the first; in seven species they are relatively longer (or narrower). In three species the first molar, and in three species the second molar is broader on the left than on the right side; in the remaining cases the teeth are equal. Interesting relationships

LOWER MOLARS IN NEW WORLD MONKEYS

	Right						Left					
	M_1			M_2			M_1			M_2		
	L'gth	B'dth	Ind.	L'gth	B'dth	Ind.	L'gth	B'dth	Ind.	L'gth	B'dth	Ind.
	mm	mm		mm	mm		mm	mm		mm	mm	
Cebus hypoleuc. 14,156 Male	4.2	4.2	*100.-*	4.–	4.2	*105.-*	4.2	4.2	*100.-*	4.–	4.2	*105.-*
Pithecia pith. 38,432 Male	3.5	3.5	*100.-*	3.5	3.5	*100.-*	3.5	3.5	*100.-*	3.5	3.5	*100.-*
Leontocebus illigeri 38,749	3.3	3.2	*97.–*	3.3	3.2	*97.–*	3.3	3.2	*97.–*	3.3	3.2	*97.–*
Saimiri sciureus 35,802 Male	3.–	2.9	*96.7*	2.8	2.8	*100.-*	3.–	2.9	*96.7*	2.8	2.8	*100.-*
Ateles ater 194,337 Female	5.–	4.8	*96.–*	5.05	4.8	*95.1*	5.–	4.8	*96.–*	5.05	4.8	*95.1*
Cebus capuc. 114,848 Female	4.8	4.5	*93.7*	4.–	4.02	*100.5*	4.8	4.5	*93.7*	4.–	4.02	*100.5*
Ateles geoffroyi Female	5.–	4.5	*90.–*	4.7	4.5	*95.7*	5.–	4.5	*90.–*	4.7	4.5	*95.7*
Lagothrix cana 35,177 Male	6.–	5.–	*83.3*	6.2	5.3	*85.5*	6.0	5.2	*86.7*	6.2	5.5	*88.7*
Alouata seniculus 194,309 Female	7.2	6.–	*83.3*	7.8	6.–	*76.9*	7.2	6.–	*83.3*	7.8	6.–	*76.9*
Pygathrix rubic. 153,793 Female	6.0	4.5	*75.–*	6.0	4.9	*81.7*	6.0	4.5	*75.–*	6.0	4.9	*81.7*

and differences appear between the various species, but consideration of these would be irrelevant to this paper.

As to the monkeys of the New World we note first of all the curious fact that the indices of the crown, with the exception of three species, are all quite high, ranging from mesodont to the lower confines of brachydont. We also note that in the larger species with crown index of 90 or above, in not less than four the second molar is smaller than the first, while in two of the species it is of the same size and in only one it is a trace larger. This holds true on both right and left side. In the three species with crown index below 90 the second molar is in all cases the larger.

The meaning of these facts is not clear. There is really little if any connection between these data and the subject of this paper and they are merely given for the sake of greater completeness.

FOSSIL APES

A comparison of far greater importance would be that of the Piltdown teeth with those of Old World fossil apes of large size. Such data, unfortunately, are difficult to secure. We have, however, a few valuable measurements on the two principal species of Dryopithecus:

In 1908, in his "Der Unterkiefer des Homo Heidelbergensis (4°, Leipz.,), O. Schoetensack, in quoting measurements by other authors on the lower molars of various anthropoid apes, gives also the following measurements on the teeth of *Dryopithecus font.* the source of which is not stated.

	Lower M_1			Lower M_2		
	Length	Breadth	Index	Length	Breadth	Index
	mm.	mm.		mm.	mm.	
Dryopithecus font.	10.5	9.–	*85.7*	12.–	10.5	*87.5*
" "	—	—	—	11.5	10.5	*91.3*

In 1898, W. Branco in "Die menschenähnlichen Zähne aus dem Bohnerz der Schwäbischen Alb" (8°, Stuttgart, Pt. 1, 43-48,), gives the measurements of the lower (as well as upper) fossil molars attributed to *Dryopithecus rhenanus*.

LOWER MOLARS NOT IDENTIFIED AS TO SIDE

	Length	Breadth	Index	Length	Breadth	Index
	mm.	mm.		mm.	mm.	
Bohnerz Teeth	13.1	11.–	*84.–*	11.–	9.3	*84.5*
("Dryopithecus	12.–	9.8	*81.7*	11.1	9.–	*81.–*
rhenanus")	11.8	9.8	*83.–*	11.–	9.2	*83.5*

These lower molars compare with those of the Piltdown jaw as follows:

THE TEETH OF THE PILTDOWN JAW AND THE DRYOPITHECUS

	The Piltdown Teeth	*Dryopithecus rhen.* (Branco)			*Dryopithecus font* (Branco)
	mm.				mm.
Lower M_1 Length	13.–	(Teeth not identified as to M_1 or M_2)			10.5
Breadth	11.–		1 tooth	5 teeth	9.–
		L.	13.1	11-12	
Index	*84.6*	B.	11.–	9-9.8	*85.7*
		I.	*84.–*	*81-84.5*	
Lower M_2 Length	13.–				12.–; 11.5
Breadth	11.3				10.5; 10.5
Index	*86.9*				*87.5*; *91.3*

The conditions shown in this table are a serious surprise. Here is a line of large apes, from ancient western Europe, the lower molars of which, in shape, and in one case even in size, resemble more than those of any other group of Primates or man, the teeth of the Piltdown jaw. What is this?

The general resemblance in type and size as well as the marked difference in relative dimensions of the fossil teeth in question to and from those of man have been brought to our attention by W. Branco (*op. cit.*); but their remarkable closeness in the relative and in one case also in the absolute dimensions to the teeth of the Piltdown jaw, is a new fact.

What is its meaning? Are the resemblances merely accidental, or do they have deeper foundation?

The teeth that most closely resemble those of Piltdown are those of *Dryopithecus rhenanus* Pohlig (Schlosser, M., *Zool. Anz.*, 1901, XXIV, 261). They belong to a relatively large series of fossil teeth gathered previous to 1850 by workingmen in the "Bohnerz" formation of the Schwabian "Alb", near the village of Salmendingen and in the general neighborhood. These teeth were first supposed to be human. They were thoroughly described and illustrated in 1898 by Branco who attributed them to an ape of the *Dryopithecus* type, and in 1901 the form they represent received by Schlosser the name of *Dryopithecus rhenanus*.

Casts of the unworn crowns of six of these teeth, three upper and three lower molars, kindly loaned by Dr. William K. Gregory of the American Musuem of Natural History, lie before the author. The three upper molars are similar in size to those of man, and are remarkably human-like in both dimensions and form, differing only in the detailed sculpture of the cusps, which is not human. Of the lower molars, one is so much larger (13 x 11 mm.) than the two others represented in these casts (11.5 x 9.3, 10 x 9.2 mm.) and shows such differences from the smallest of the three teeth, that it is hard to conceive of it as belonging to one and the same species or variety. It is this large tooth that is practically identical in crown measurements and in index with the Piltdown molars. In details, however, the two differ. The Bohnerz molar resembles more some lower human molars (though differing somewhat from these in detailed sculpture—particularly in the presence of a marked anterior and smaller posterior median fossa in the occlusal surface of the crown), than those of Piltdown. The Piltdown teeth, especially the second molar, are remarkable through being almost as stout posteriorly as anteriorly; the Bohnerz tooth, behind the second cusps, distinctly tapers backward and inward. The Piltdown molars are of a distinct type from this fossil tooth, notwithstanding fundamental relations. The Piltdown being was not a Dryopithecus, but may have had ancestral relations with some species of this genus or family as close as those with the chimpanzees, if not even closer. A theory that the Eoanthropus may have evolved from such apes as represented by the Bohnerz molars, and that perhaps all man's evolution took place in western Europe, is a very seductive one and may possibly prove true, but it would be premature to give undue weight to this hypothesis. The remains of *Dryopithecus rhen.* appear to be of late Miocene or early Pliocene age, which would seem to give plenty of time for the develop-

ment from the type represented by the Bohnerz molars of such differences as presented by the molars of the Piltdown jaw, but the evidence at hand hardly warrants as yet such far-reaching assumptions. Nevertheless, the near-human character of the Bohnerz teeth together with some of the features of the Piltdown molars are a strong incentive for our giving a greater attention than in the past to the remains of the European fossil Primates.

SUMMARY AND CONCLUSIONS

The peculiar molars of the Piltdown jaw connect, though in respect to their length and crown index only at the base of the range of variation, with the teeth of man of to-day.

They connect more closely with the more ancient teeth of Early Man and may without violence be included among them.

They do not connect with the teeth of any of the living forms of anthropoid apes, though in general these are nearer to them than most man's teeth in the crown index.

In relative, and in one case even in absolute proportion, they resemble very closely the teeth from the Bohnerz Alb attributed to *Dryopithecus rhenanus*, particularly one of the lower molars; but in morphological details they differ from these, being more human.

The only conclusion that appears justified from these further as from previous studies is, that the Piltdown teeth, primitive as they are in some respects, are already human or close to human. Their characteristics speak for their belonging either to a very early man or his very near precursor.

The close relation of the Piltdown molars to some of the late Miocene or early Pliocene human-like teeth of the Bohnerz Alb, as well as to those of the Ehringsdorf jaws, while not conclusive alone, raises legitimately the query as to whether man may not have evolved altogether in western Europe.

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HUMAN SKELETAL REMAINS FROM THE HIGHLANDS OF PERU

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INTRODUCTION[1]

During the Peruvian Expedition of 1914 and 1915 under the auspices of Yale University and The National Geographic Society, a series of human skeletons, crania and mummies (fragmentary specimens included) was gathered from caverns in the highlands northwest of Cuzco. The localities in order of yield are : Paucarcancha 192; Patallacta (Qquente) 92; Torontoy 30, Huata 17, Yanamanchi and Sillque 4 each, Huispang 1, and Huarocondo 1. All these localities with the exception of Yanamanchi are in the drainage basin of the Urubamba river. At the request of Professor Hiram Bingham, Director of the Expedition, the author has undertaken a detailed study of the collection.

From Paucarcancha by way of Patallacta to Torontoy (the three chief sites), is scarcely eight miles by the map; from Torontoy and Yanamanchi on the extreme northwest to Huarocondo, the most distant site on the southeast, is not over forty miles. Machu Picchu, explored by an earlier (1912) Yale Peruvian Expedition under the direction of Professor Bingham, is not over eight miles in a straight line to the northwest of Torontoy; so that the entire area is to be looked upon as an ethnic unity at the time when these caverns were made use of by the ancient inhabitants of Peru. The stock is apparently the same as that which left its remains in the caves and *chaukallas* of the provinces of Yauyos and Huarochiri in the direction of Lima.

LOCALITIES, MUMMIES, BURIAL CUSTOMS

PAUCARCANCHA.—The name is derived from two Quichua words: *paucar*, meaning beautiful and *cancha*, meaning locality. The ruins are situated at an elevation of 10,000 feet, near the junction of the Rio Qquesca with the Rio Pampaccahuana, one mile above the village of Huayllabamba, and five miles above Qquente where the Pampaccahuana flows into the Urubqmba (Pls. I, II, IV).

On May 2, 1915, an Indian guide pointed out to Elwood C. Erdis the location of a big cave some 400 feet from the stream. The width of the entrance was eight feet and Erdis estimated that there were at least 25 skulls in sight. The following day, with the guide and three men,

[1]By the time these pages shall have been printed the bones to which they are dedicated will probably be on their return journey to the land of the Incas, and to the peaceful oblivion from which they were unceremoniously awakened by Professor Bingham's last Yale Peruvian Expedition. To him, to Mr. Osgood Hardy and to the Expedition the author's thanks are due for services rendered.

Erdis returned to the cave. According to his diary, 127 skulls and only two small sherds were taken out on this first day of exploration. On the next day, enough skulls were removed to make an even 200. Of the total 172 came from the central part of the cave and 28 from the left side. Erdis also records the finding of a bone needle with part of a mummy at the extreme back of the cave, and a large bronze topu or pin.

The big cave is 100 yards below the marked chulpa in the ravine, the latter being 200 feet above the mouth of the Qquesca. The entrance was walled up to a height of about two feet, which left an opening of 18 inches. The depth of the cave is given as 16 feet and its height 2½ feet. Not only were there skulls and bones in the wall at the entrance but inside they were "so packed and jumbled together" that Erdis made no attempt to separate them. He also adds: "am only saving mummified bones or deformed ones and skulls and jaw bones." The mummified specimens were at the back of the cave, lying flat and jumbled together. This means in part at least that their location tended to retard decay. Bones were found down to a depth of 30 inches (75 cm.) in the floor of the cave.

In regard to the mummies and their wrappings, Erdis states that a "good deal of dried grass and coarse rope were used on the heads of skeletons." One mummified skeleton (cat. no. 39) had a piece of knotted red cord at the waist (Pl. VI), while cloth marks were visible "over forehead and eye" of another. A portion of a mummy (cat. no. 122) "had a rope over head and around neck." Another mummy "has brown outer and blue inner cloth around it" (cat. no. 627). A mummy with a trephined skull (Pl. III) had a wrapping of coarse matting and cord about the waist. At the mouth of one skull (cranium, lower jaw, and portion of the coarse mummy wrappings, cat. no. 40), Erdis found what he called a rabbit mummy, but Dr. G. F. Eaton has identified it as that of a guinea pig. Whether this animal was left there whole by pious hands as food for the departed, or whether it crawled into the cave to die, would be difficult to decide.

Whatever the position of the mummies when found, they were originally put away in a sitting posture. This is indicated not only by the attitude the mummy was forced into before and during the process of wrapping, but also by the presence of seat rings composed of withes twisted and held in place by strips of bark and cords. A number of these seat rings were secured, some complete, others fragmentary (Pl.VI. The arms were flexed to the limit at the elbows; and the elbows were pressed against the sides. The wrists were brought together on the

upper part of the chest, the hands extending to the chin. The legs were just as sharply flexed at the knees, which brought together between and somewhat above the laterally placed elbows. Like the wrists, the ankles were pressed tightly together, against the pubic arch. In the case of males the sexual organs were carefully pulled straight forward over the pubic symphysis and held up in that position by the pressure of the ankles in front of them. This method was employed in all male mummies that were complete enough to admit of the necessary observations (at least four examples, three from Paucarcancha and one from Torontoy.)

The mummy wrappings consist for the most part of coils of coarse grass rope; these coils are sewn together by means of grass rope of a much smaller size. One of the best preserved examples (cat. no. 123) is seen in plate VI. At the base of the coil is the seat ring. The view (no.1) is from the side showing the major part of the left ilium and the sciatic notch. The sharply flexed knees protrude from the wrappings.

The same specimen resting on the back is also shown in the illustration (no.2). At the bottom are the sacrum and coccyx. Just below the center the pubic angle is visible; on each side of and slightly above it are the heels and soles of the feet. The seat ring of withes passes above the toes at the top, and between the pubic angle and the sacrum at the bottom. It is held together by strips of bark or fibre, and the mummy wrappings by means of the small-sized grass rope distinctly visible at three points.

Erdis, as stated, collected 200 skulls in the big cave at Paucarcancha. He also found three skeletons including the skulls, of a man, woman and child, in a grave under house 16–I; and according to the records, two other skulls were purchased. This would make a total of 205 crania. But a catalogue made by the author after the arrival of the collection in New Haven accounts for only 192 skulls complete or fragmentary, including the five specimens not found in the cave, or only 187 from the cave.

Of these 192 skulls, 77 are male, 64 female, 8 of uncertain sex, 4 of youths, and 29 of children. Only 118 are sufficiently complete and of the proper age to be measured as a whole or in the major part. Among these, the male crania number 64, the female 50, and in only 4 is the question of sex uncertain. In all except the few mummified heads and the three skulls from the grave under the ruins, the lower jaw had become separated from the cranium; but by a long and tedious process of matching over two dozen lower jaws were finally fitted to their respective crania, making a total of 36 in this category. There remain a total of

95 lower jaws that cannot be placed; it is safe to assume, therefore, that the skeletal remains from Paucarcancha represent more than the 192 individuals listed in the catalogue.

Of the triple burial in house 16–I, the skeletons were encountered at a depth of 2 feet 5 inches under a pile of rocks. The bodies were buried in a reclining position with arms and legs flexed. The bones were much intermingled and friable. The skull of the child was near the breast of one of the adults. Part of the female skeleton (cat. no. 139) is shown in Pl. V. A few sherds of plain ware were found with the skeletons, also several bones of the llama. After the burial the house had been deserted.

PATALLACTA.—This is the name given to important ruins near Qquente (humming bird) at the junction of the Pampaccahuana with the Urubamba, some five miles below Paucarcancha. The word comes from two Quichua roots: *pata* above, and *llacta* town or place, in other words a city on a hill (Plates VII–X).

According to Sir Clements Markham,* Pachacuti, one of the greatest of the Inca rulers, when dying ordered that his body should be placed in his palace of Patallacta. (For all we know to the contrary, this may be the Patallacta referred to by Pachacuti). The same author states that Llactapata and Colcampata are synonyms of Patallacta. In fact just below Hollidia and across the Pampaccahuana from Patallacta, Erdis found a group of houses which the Indians call Llactaspatas. Here are "four or five baths or fountains and a fine big two-storied gabled house, or rather two with common gable like that at Machu Picchu." This house is called a good find in lintel construction. The dividing wall is almost 25 feet high. The north gable has five cylinder stones on one side and four on the other. Near the house is one side of an ornamental gate. Some of the baths have cut stones. There are three springs of water. Nearby were found some bones (including a piece of skull) and a lower jaw. It is a small place but Erdis thinks "some chiefs must have lived there."

The work of excavating at Patallacta was under the personal supervision of Erdis and J. J. Hasbrouck. In the immediate vicinity of Patallacta, Professor Bingham noted many signs of ancient irrigating ditches, ruins of smaller villages, and a few ruins of well-built houses; but the stone work is inferior to that at Machu Picchu.

The burial caves at Patallacta are near the ruins. They were located and explored. According to Erdis, they visited "one cave with 15 skulls in sight (one of which was syphilitic), another with 18 skulls in sight

*The Incas of Peru, N. Y., 1910.

(70-H), one of which had five trepanations (see pl. XXI); while in a third cave, 26 skulls were visible. He also mentions a number of caves with one or two skulls. This was on May 8, 1915. The caves were not opened till later; for under date of May 26, Erdis states that they had "about half hunted caves 68-H, 69-H, and 70-H, northwest of the town. Got a lot of skulls, a syphilitic one (cat. no. 635) and a lot of same kind of bones; one skull with five trepans, and a lot of ropes and cloth."

In the meantime they had explored cave 66-H (Pl. VIII) on the terrace 60 feet south of the fifth or lowest bath of the main stairway at the ruins. Hasbrouck's men found this big cave while clearing. From it Hasbrouck, and Erdis took some rope and mummy cloth, 16 skulls, many sherds, and a small olla. The following day (May 22) they continued search in cave 66-H, where they found a needle of chonta wood, more rope, three new kinds of ollas, a broken gourd, many skull fragments, and sherds. The ollas were all on the floor of the cave at a depth of four feet.

The cave had a partition of adobe and stone 18 inches thick. To the other side of this partition, Erdis gave the number 67-H. He speaks of finding a small broken olla at a depth of one foot in front of the cave; and then goes on to enumerate finds as follows: a lot of sherds (270 in all), another pierced bone at a depth of one foot, a comb of chonta wood 2.5 inches square (at a depth of 18 inches), rope and sherds; but he does not say whether they were found in the cave or outside. In the south end and walled in by itself, he found part of a headless mummy with cloth wrappings about the hips, a pierced and decorated bone pin, a small burial olla, inside of which were some ashes, a short bronze topu one foot deep at the front of the cave, and in the cave a very small olla. Llama bones and corn cobs were taken from both parts of the cave, and in both parts the floor in the center showed marks of fire down to a depth of from three to four feet, and many skulls and bones were charred and broken.

The mode of wrapping the mummies and the materials employed were the same as at Paucarcancha; seat rings of twisted withes, coils of coarse grass rope, and cloth.

Our catalogue shows a total of 92 crania from the caves of Patallacta: 34 males, 22 females, 13 youths, 16 children, and 7 adults of uncertain sex. In only five is the lower jaw associated with the skull, while the collection includes 34 lower jaws that do not fit any of the crania present. A number of the skulls are fragmentary. In some the field number is no longer visible; but nearly all are known to have come from the caves numbered 66-H, 67-H, 68-H, 69-H, and 70-H, west of the town. Thirty-

seven came from cave 68-H: twelve males, eleven females, ten youths, three children, and one adult in which the sex is doubtful. Thirty-two skulls are marked as having come from the double cave on the terrace south of the fifth bath of the main stairway: eight males, four females, two youths, and two children from the half numbered 66-H; and five males, three females, one youth, five children, and two adults of uncertain sex from that numbered 67-H (Pl. VIII). Eleven are from cave 69-H: five males, one female, one youth, and four children; while only two, both adult males, bear the number 70-H. One of these has the five complete trephines and the other one trephine; and this is the cave which, according to Erdis, had 18 skulls in sight.

From Patallacta, which is on the left or west bank of the Pampaccahuana at its junction with the Urubamba, an old trail discovered by the Expedition leads to Machu Picchu, in whose caves the ratio of the sexes is just the reverse, i. e. the females largely predominate.

According to Professor Bingham, the archaeological material from Patallacta shows it to have been a pure Inca town, a conclusion supported by the style of architecture. In nearly every house were found pottery vessels of the aryballi type, beaker-shaped ollas, two-handled dishes, plates and ladles. Fragments of animal bones were plentiful, apparently for the most part, those of the llama. Professor Bingham was also impressed by the rarity of the metal objects.

TORONTOY.—Torontoy is the name given to a stopping place for travelers in the district of Ollantaytambo, province of Urubamba, and department of Cuzco. It lies on the east, or right, bank of the Urubamba, some two or three miles below Patallacta and twenty-one miles below Ollantaytambo (Plates XI, XII). Occupants of the few Indian huts supply water and food for wayfarers and feed their mules. Nearby are some beautiful Inca ruins with stone-faced terraces (Pl. XII). The ancient inhabitants buried their dead in a large cave in the cliff back of and some four or five hundred feet above the ruins. The presence of this cave was reported by Edmund Heller of the Expedition, who had heard of it through an Indian. It was explored by Professor Bingham and Mr. Osgood Hardy. On account of its almost inaccessible position the empty boxes were passed up by means of an improvized pulley; they were filled by Professor Bingham, and then let down to Hardy, who remained below. The cave served also as a refuge for vampire bats (*Desmodus rotundus*), that sucked the blood of the mules of the pack trains which passed the nights at Torontoy. In order to rid themselves and their guests of this pest, the natives had recently burned out the cave

by setting fire to the mummy wrappings within, with the result that much of the skeletal material was either destroyed or seriously damaged before the arrival of Bingham and Hardy. Some of the material they gathered is so badly injured by the fire as to be of little scientific value. On the other hand they secured a few specimens that are of special interest. The fragmentary mummy wrappings that escaped the fire are of the same general character as those from Paucarcancha and Patallacta. One of the mummies is shown in Pl. V.

Fourteen of the skulls from the Torontoy cave are of the male sex, ten are female, two belong to youths, and four to children, making a total of thirty. In thirteen of these the lower jaw is present, and there remain only three lower jaws for which the proper skulls have not been located.

SILLQUE.—Following up the Rio Urubamba from Torontoy in a southeasterly direction toward Cuzco for some nine miles, one comes to Sillque on the left bank of the river and just above the mouth of the tributary Rio Sillque. Here were found in August, 1914, the cranium and lower jaw of a male and the crania of three children, to one of which the lower jaw was attached. In addition to these there are the headless mummy of a child, the mummified foot of an adult female, perhaps its mother, inner and outer mummy wrappings of cloth, a flat rope of wool and a rope of coarse grass. One of the wrappings is of very fine, the other of medium weave.

HUISPANG.—From Sillque it is only about five miles up the Urubamba to Ollantaytambo, the headquarters of the Expedition of 1915. Another five miles brings one to the mouth of the Rio Huarocondo, one of the southern tributaries of the Urubamba. On this tributary or its branches, human skeletal remains were found at three localities: Huispang, Huata, and Huarocondo. The ruins of Huispang are not more than five miles from the mouth of the Huarocondo (Plates V, XIII).

Some 200 yards above Huispang at the foot of a cliff, Erdis and C. F. Westerberg found a cave that had already been opened. On the outside, ten feet from the mouth, was a human skull with a cleft palate (Pl. XIV), and not more than six feet from the skull was the lower jaw. The remainder of the skeleton complete with the exception of some of the wrist and ankle bones and phalanges, was inside and apparently in situ, extending from the surface to a depth of two feet. The arms and legs had been flexed in the usual fashion, bringing the hands to the chin and the feet to the angle of the pubis. A few animal bones, including the femur and the calcaneum of a dog-like form, *Icticyon venaticus*,* were found with

*Determined by Professor R. S. Lull and Dr. M. R. Thorpe, calcaneum and femur belong to different individuals but to the same species.

the skeleton, which is that of an adult male. All the bones are in an excellent state of preservation. In size, age, and sex the skull corresponds with the rest of the skeleton, and the atlas articulates perfectly with the occipital condyles, so that the bones can be referred to one and the same individual. Some badly decayed mummy cloth was also obtained from this cave.

HUATA.—Less than five miles up the Rio Huarocondo is the mouth of one of its small tributaries, Rio Chillipampa. On the south or left bank of the Chillipampa, at an elevation of 12,400 feet, is Huata (Pl. XIV); in its environs a number of graves were opened in August, 1914, by Erdis, Westerberg, Means, and Meserve. "Huata" is a geographic Quichua term in common use; it means *year*. To the north of Huata, in the direction of Huispang, is a fine ruined village reported by Westerberg. The local camp of the Expedition was one and a quarter miles to the west of Huata. Below the trail some fifteen feet they found an open grave; one small leg bone had been left in it. Just below the grave were a lot of human bones that had been thrown out and were still partly dirt-covered. Above the trail on a point and 25 feet distant, Erdis noted an "open bottle-shaped or circular grave." Seventy-five feet above the trail and 450 feet west of the saddle, there were four skulls and a lot of bones under the face of a cliff thirty feet long. They took only one skull. The left half of the posterior end showed above the dirt; a broken skull was beside it.

On top of the point (no. 8) 200 yards west of the saddle, lay a lot of bones including the broken skull of a youth with Aymara deformation, and a number of lower jaws. On the south side of the point, on a level with the saddle and 500 yards west of it, is a spring or pool four feet across, the walls of which are now in ruins. Miscellaneous sherds were gathered in this vicinity.

On the east point east of the houses and fifty feet below, Westerberg discovered an open cave (no. 9) in which were two skulls; one of these (cat. no. 877) had three artificial apertures and one deep indentation (Pl. XXI). The other skull was not taken.

A majority of the skulls collected were gathered from caves on the "east side of Huata." Cave no. 11 (Pl. XIV) is on the point 200 feet east of the adobe houses and 100 feet lower; from this open cave nine skulls were taken by Erdis, Meserve, and Means. At the top were two mummies in the usual attitude of flexed extremities, and lying face downward one across the other. Underneath were three or four skeletons, from which the soft parts had wholly disappeared. On the same level

as the two mummies was the skeleton of a child. The skull of one of the mummies had been subjected to trepanation for a depressed fracture. From cave number 11 came also an interesting pathological specimen: a forearm with fused elbow joint and osteo-myolitis of the humerus (cat. no. 901, Pl. XXXVIII). According to Erdis there was a deposit of charcoal and ashes two feet thick on which the skeletons rested.

One of the interesting features relative to the skeletal remains from cave number 11 is the marked similarity between two of the crania (cat. nos. 880 and 881). Number 880 is a male about 24 years old and number 881 is a male of approximately 28. They are enough alike in every detail to have been twin brothers, even identical or monozygotic twins; they were most certainly blood relatives. Both have the metopic suture and simian gutters. Neither is intentionally deformed; but both are plagiocephalic and in exactly the same sense. While the wormain bones are more plentiful in 880 than in 881, their distribution is the same. The denture is the same except that a third molar is lacking on the right side in 881. In shape the dental arches are strikingly similar. The topographic features are moulded along parallel lines (Pl. XV), and the craniometric data coincide to a remarkable degree. However, the skull of the younger man (880) is the larger. It has actually the greatest capacity of any cranium in the collections of the Expedition (1670 cc.) The two skulls have exactly the same breadth (14.4 cm.). The maximum circumferences are 51.4 cm. and 51.0 cm., and the nasion-opisthion arcs 38.5 cm. and 38.1 cm. respectively. The thickness of the parietal is the same in the two. The maximum bizygomatic diameters are 13.9 cm. and 13.8 cm. The length of the nose is the same (5.0 cm.) and the breath 2.6 cm. and 2.4 cm. The breadth between the orbits is the same (2.7 cm.) in each. The prosthion-akanthion measure is 2.2 cm. in the larger and 2.1 cm. in the smaller. The alveolar angle is 59 in both. The length of palate for the larger is 4.4 cm. and for the smaller 4.3 cm.; the breadth of palate is 4.2 cm. and 4.1 cm. respectively, and the length of the dental arch is precisely the same (5.3 cm.) in both. The older cranium has the larger mastoid processes, but this may perhaps be accounted for, in part at least, by the difference in age. While the sutures in the younger are much finer, they resemble those of the older in type. What appears to be an example of trepanation by means of scraping or cauterization over an oval area 4.5 by 3.7 cm. is situated between the right parietal eminence and the obelion of the older skull.

From an open cave (no. 10) twenty-five feet farther up the hill than

cave 11, Erdis and Meserve took two trepanned skulls and one with Aymara deformation. At the foot of the slope to the right of and below cave 11, Erdis and Meserve found a weathered skull (cat. no. 885); it might have come from any one of four caves.

Of the 17 skulls from Huata, 8 are males and 6 females; one is of a youth and two are of children.

Although five miles up the river from Huata, the elevation of Huarocondo is less, being only 11,200 feet.

HUAROCONDO.—The site is a cave on the Rio Huarocondo one mile below Huarocondo. Here in 1914 Meserve found a male skeleton. According to the diary of Erdis they got every bone making a complete skeleton (cat. no. 923). He describes the body as being "straight up" with arms and legs flexed and the right hand under the right ear (Pl. XIV). The feet were in position with toes forward. The skull was separated somewhat from the neck vertebrae. It is undeformed, robust, and dolichocephalic. The foramen magnum is large and the mastoid processes prominent. Of the fifteen teeth still in situ, three are decayed. The external table had been removed over an oval area 12 by 21 mm. in diameter between the left parietal tuber and the sagittal suture; the reasons for it are not manifest, but the healing is complete.

YANAMANCHI.—The hamlet of Yanamanchi is on the left bank of the Rio Lucumayo at an elevation of 11,100 feet and seven leagues* to the northwest of Ollantaytambo. The ruins are on the property of De la Torre of Cuzco, and the road house is kept by Angel Manteagudo. Just above his house, which has three niches in the back wall (outside), are three great halls each about 45 feet long. One has a width of 18 feet, and the other two about 27 feet each. In the back wall of one there are ten niches. Scattered through the brush are many more houses and walls, all more or less in ruins. They are of rough granite and slate masonry laid in adobe or clay mixed with gravel. Erdis obtained four skulls from caves under boulders. The skull from grave no. 2 (cat. no. 911) has a large frontal trepanation involving the loss of bone over an area 60 by 52 mm., the field of operation reaching from the right brow ridge to within 25 mm. of the coronal suture and to within 33 mm. of the bregma. The weathered condition of the skull makes it impossible to say whether the bone had healed after the operation. From an open cave (no. 4) was taken the skull with pronounced Aymara de-

*In parts of Peru a "league" is the distance a mule can travel in one hour. While the distance between Ollantaytambo and Yanamanchi measures not more than eleven miles on the map it takes a mule seven hours to cover it, hence seven leagues.

formation (cat. no. 912). Two of the skulls belong to the male sex, one is female, and one that of a youth. In the opinion of Erdis a further search would have resulted in the finding of much additional skeletal material.

From what has gone before it is evident that the ancient burial customs were the same at all the sites herein described. Not only were natural rock shelters utilized as communal burial places; but boulders were also made to serve as shelters for one or more skeletons. The larger rock shelters were sometimes divided by means of a partition, the one at Patallacta being a good example. These natural shelters or caves vary in size, one of the largest being the big cave from which portions of at least 200 skeletons were taken. At Huata, Erdis noted an "open bottle-shaped or circular grave."

Similar burial customs were in vogue at Machu Picchu, if we may judge from the details given in the memoir by Dr. Eaton. Like customs were no doubt practiced in the highlands from the southern to the northern boundary of pre-Columbian Peru and even in Equador. Hrdlička has reported on the subject[1] in southern Peru; while Dr. Rivet of the Museum d' Histoire Naturelle, Paris, who spent five years in Equador, describes the important collection of human skeletal remains he found in the rock shelters of the Jubones valley especially at Paltacalo[2].

The source of the Rio Jubones is in the inter-Andean plateau south of Cuenca; after traversing the western cordillera, it empties into the Pacific north of the city of Machala. About midway of its course and some distance back from its left bank is Paltacalo, in the environs of which Rivet obtained 138 crania for the most part in a good state of preservation, also numerous bones from other parts of the skeleton. The rock shelters from which these were taken are on the mountain spurs that flank the affluents on both the north and the south sides of the Jubones. In addition to the rock shelters, burials were also found in artificial monticules or *tolas*. In the same region Rivet likewise found sepultures of a totally different nature: large circular pits or wells, which occur even on the banks of the Jubones, and which recall bottle-shaped or circular graves found by Erdis at Huata.

The most productive rock shelters were on the mountain at Paltacalo, especially near its summit and on the northern slope. Even the small rocks were utilized as shelters for single burials. The larger shelters

[1]Anthropological Work in Peru in 1913, with Notes on the Pathology of the Ancient Peruvians. *Smiths Misc., Coll's.*, 1914, No. 2246.

[2]*Bull. Mém., Soc. Anthr.* Paris, 1908, IX, 209, 314.

generally contained the remains of many burials. Pottery in a fairly good state of preservation was the usual accompaniment. The entrance to the rock shelters at Paltacalo was so effectively sealed by means of stone walls that the animal bones found within are supposed to be contemporary with the pre-Columbian population of the region.

In his History of Ecuador, F. Gonzales Suarez* states that certain tribes placed their dead in rocky cliffs, choosing for this purpose the most elevated and inaccessible points, and Hrdlička (op. cit.) saw similar conditions in Peru in the mountains east of Lima as well as further southward. There is no doubt therefore that similar burial customs prevailed in the highlands of both Ecuador and Peru. Of the 138 crania collected by Rivet, 37 or approximately 27% were intentionally deformed. This is considerably below the percentage (45) of deformed crania from the Peruvian sites in question. He did not however report on the type of deformation, whether Aymara, or coastal, or both.

INTENTIONAL DEFORMATION

As is well known, there are in Peru two distinct types of intentional deformation of the head: the coastal type, which consists of fronto-occipital flattening, and the highland or Aymara type, produced by circular constriction and compensatory elongation. The latter was employed almost exclusively in the region under consideration. With the exception of Sillque, it was represented at all the localities which yielded more than one or two crania. Out of a total of 341 skulls 147 were thus deformed, and some of the other specimens are so fragmentary as to be doubtful. On the other hand there is not a single adult cranium with anything like a pronounced fronto-occipital flattening, and only a very few in which there is the suspicion of even a trace of such flattening. Intentional deformation, which here means aymara deformation, was more in vogue with the female sex than with the male. For example, the collections include 133 adult male skulls, of which 58, or 43%, are intentionally deformed; they include 107 adult females, of which 64, or 60%, are intentionally deformed. There are nine adult skulls in which the sex is doubtful; six of these are deformed and three are not. The presumption therefore is that over half of the doubtful skulls might be classed as female because of the relatively great frequency of intentional deformation among them. This showing is at variance with conditions elsewhere (Hrdlička), and may perhaps be accidental.

*Historia general de la Republica de Ecuador, Quito, 1890, I.

In many cases the degree of distortion is only slight, so insignificant in fact as not to interfere with the inclusion of such skulls in the table of craniometric measures. In others the distortion is extreme. The most highly deformed of all the crania is that of a female from Patallacta (cat. no. 636). The age is about 30. This is also one of the skulls in which there is a temporo-frontal articulation, and a wormian bone at the posterior angle of the pterion on both sides. Other anomalies are: a paired hypo-glossal canal on the left side and a displaced left upper canine, in which the lingual surface faces toward the incisors. The palate is relatively short. The skull bears no marks of disease, neither had it been trephined (Pl. XXXVI).

An example of Aymara distortion almost equally extreme is present in the skull of a male from Torontoy (Cat. no. 760). In other respects than deformation the two skulls are very much alike, especially in the shape of the dental arch and lower jaw as well as the dentition. Instead of the reversed pterion however the male cranium has the usual spheno-parietal articulation on both sides. The premature obliteration of the sagittal suture might have had something to do with preventing a still further elongation in the direction of the obelion. There is also to be noted the anomaly of a foramen pterygo-spinosum on the right side (Pl. XXXVI).

Noting that the foramen magnum of the extremely distorted skulls seemed smaller than in the undeformed or only slightly deformed, I chose six of the female crania from Paucarcancha having the most pronounced distortion, for comparison with six undeformed female crania chosen at random from the same locality. In the deformed series, the average length of the foramen magnum is 3.3 cm. and its average breadth 2.7 cm.; for the undeformed series these measured are 3.7 and 2.9 cm. respectively. It would seem therefore that Aymara deformation when carried to excess tends to reduce the dimensions of the spinal canal at its uppermost portion. I went a step further to see if a corresponding difference could be detected in the average cranial capacity of the two groups, and obtained wholly confirmatory results. The average capacity for the deformed group is 1,213 c.c., while that of the undeformed group is 1,288 c.c. Although the two groups are comparatively small, they are of the same number, sex, and racial type as well as from the same locality; and the differences both in respect to size of brain and of spinal cord are so marked as to do much toward supporting the conclusions based on them, viz., that excessive Aymara deformation has an inhibitory effect on the growth of the brain and possibly also the spinal

cord. It is to be hoped that other observers may test this matter when opportunity presents itself.

On the other hand, excessive Aymara deformation does not seem to have any effect on the size of the external auditory meatus. This was all the more surprising because of the author's previous observations on the large Yale collection of Flathead Indian skulls from Oregon. In nearly every one of the Flathead skulls the fronto-occipital flattening had tended to reduce the size of the external ear opening, at times almost closing it.

In addition to the prevalent Aymara deformation, there are in the collection a number of skulls that are unintentionally deformed. One of these, a female skull from Paucarcancha (cat. no. 54) is asymmetrical, especially in norma posterior aspect, due to cradle deformity affecting principally the right mastoid region. Another, a male skull (cat. no. 129) is asymmetrical in a like manner, but on the opposite side and back of the left mastoid process.

At least five of the crania are plagiocephalic, a deformity seen in the norma verticalis. In crania of this sort, the two oblique diameters which form the so-called trapezium of Welcker, are unequal. Plagiocephaly may be synostotic, following the premature obliteration of diagonally opposite branches of the coronal and lambdoid sutures; it may also be due to a cradle deformation.

Another characteristic deformity is scaphocephaly, in which the cranium presents the aspect of an inverted boat. Its main cause is the premature obliteration of the sagittal suture. Little more than a bare suggestion of scaphocephaly is met with and in only two crania; in both not only is there lacking any premature obliteration of the sagittal suture, but in each the metopic suture is present (cat. nos. 42 and 883).

ETHNIC TYPES

The almost complete absence of fronto-occipital flattening and the relatively great frequency of the Aymara deformation in the region under consideration, point to a great predominance there of the highland type as opposed to the brachycephalic coastal type.

Curiously enough a slight Aymara deformation has practically no effect on the cephalic index of the skull. Another surprise is the fact that the crania with lowest cephalic index are undeformed skulls; and the same is true of skulls with the highest cephalic index. The latter group is a very small one. There are for example, only ten (4 male and 6 female) crania with a cephalic index of 80 and over (80.2 to 82.9). Eight of these

are undeformed; while in two there is a barely perceptible deformation (Aymara?).

About the same ratio of undeformed to deformed skulls holds in the series of 51 (30 male, 18 female, and 2 of uncertain sex) with a cephalic index of 75 and under (75 to 69.7), and here also the deformation is scarcely to be detected. The cephalic index of a great majority of the crania falls between 75 and 80.

Much has been written concerning the presence in various parts of South America, and even on the Pacific coast of North America, of a paleo-American race, the so-called race of Lagoa Santa. The discovery of human skeletal remains associated with animal remains near Lagoa Santa, Brazil, was made by P. W. Lund in 1843. Years afterward these remains were the subject of important papers by de Quatrefages, J. Kollman, H. ten Kate, et al. The great antiquity of the human bones from Lagoa Santa has never been established, but there is reason to believe that they represent one of the earliest known American types.[1]

A skeleton that has been quite generally associated with the human remains from Lagoa Santa, although the skull is brachycephalic, was found in 1881 by Santiago Roth covered by the carapace of a glyptodon on the banks of a small affluent of the Rio de la Plata at Pontimello, province of Buenos Aires. Lehmann-Nitsche[2] refers to it as the skeleton of Fontezuelas instead of using the name Pontimello employed prior to 1907.

The Lagoa Santa racial type is based on a study of 17 crania remarkable for their homogeneity. The chief characters are: relatively small capacity (average of 1,388 c.c.), dolichocephalic and high, short face, broad palate, and ample forehead. The cephalic index ranges from 67.0 to 73.5, the average being 70.71.

The type of Lagoa Santa is reported by Rivet[3] as occurring in the region of Paltacalo, Ecuador. If found there, why not also in the Urubamba valley? In fact some of the skulls from Paltacalo figured by Rivet as belonging to the race of Lagoa Santa are strikingly similar to certain skulls from Paucarcancha. For example the male skull with a cephalic index of 72.4, to which he gave the catalogue number 19,579 and the female skull (cephalic index of 72.7) numbered 1 in our catalogue, are

[1]See Hrdlicka (Ales)—Early Man in South America. *Bull. 52. Bur. Amer. Ethnol.*, Wash., 1912.

[2]Nouvelles recherches sur la formation pampéenne et l'homme fossile de la République Argentine. Buenos Aires, 1907, 319. See also Hrdlicka, *op. cit.*

[3]*Op. Cit.*

enough alike to have belonged to brother and sister. This latter skull is worthy of a brief description (Pl. XVI). It is of a female about 25 years old. The metopic suture is still distinctly visible at both ends. The face is short. A striking feature is the infantile character of the mastoid processes, which are not larger than those of a female chimpanzee. Another infantile character is the persistence of the squamo-mastoid suture. The nasal bones and the anterior nasal aperture are rather negroid in shape. The floors of the auditory meatus are defective on both sides and the walls of the carotid canals are defective. A distinct spheno-pterygoid foramen occurs on the right side. The right canine is completely fused with the first premolar, so far as the crown is concerned. The teeth were all present at the time of decease, although three had suffered some decay.

The cephalic index of the skulls from Lagoa Santa ranged from 73.5 to 67. In the Yale collection there are twenty-nine crania including the one just described with a like range of cephalic index, and these form a fairly homogeneous group.

At the beginning of the nineteenth century, Humboldt mentioned the existence of a race of "pygmies" that were said to inhabit the region of the upper Orinoco. According to Collineau and Daveluy, a Mr. Sullivan of Boston announced prior to 1898 the presence of a race of pygmies on the banks of the Rio Negro near the headwaters of the Orinoco. The height of the men was said to average about 1.42 m., while the women were still smaller. The skin color was said to be a brilliant reddish yellow and the hair straight like that of an Indian. MacRitchie and Haliburton both speak of American pygmies, their evidence being based largely on literature and legend. According to Karl von den Steinen, the Guayaqui of Paraguay are pygmies in stature. The males average 1.52 m. and the females 1.424 m.

Kollman cites examples of skeletal material with pygmy dimensions from various sections of the New World including Peru, Brazilian Guayana, and Guatemala. In the cemeteries at Ancon and Pachacamac, Princess Theresa of Bavaria found skeletons of a race having a stature ranging from 1.161 to 1.463 m. and a cranial capacity of 1,000 to 1,190 c.c. The stature and cranial capacity of the skeletal material from Maraca do not vary much from the foregoing figures.

In the skeletal material from the highlands of Peru, there is the suggestion of the presence of individuals of small stature. There is no single skeleton that could be classed as that of a "pygmy," but various skulls as well as long bones might be so classed in so far as dimensions are con-

cerned. In the series of crania from Paucarcancha, there are female crania each with a capacity less than 1,200 c.c., and two fragmentary crania the capacities of which can only be estimated but which were certainly below the figure named. Among the male crania from the same locality, there are two of which the capacity falls below 1,200 c.c., also one fragmentary cranium.

Similar evidence is furnished from other localities. From Patallacta there are eleven crania each with a capacity below 1,200 c.c., nine of these are of the female sex and two of the male sex. The list from Torontoy comprises four crania of the female sex; from Huata two crania, both female, and from Huispang and Yanamanchi one female each. Of the total number of skulls the capacity of which can be taken, 42 have a capacity below 1,200 c.c. Of these 37 are female skulls and 5 male. The arithmetic mean for the five male crania is 1,154 c.c.; the maximum capacity being 1,190 and the minimum 1,110 c.c. The arithmetic mean for the 37 female crania is 1,100.5 c.c., the maximum capacity being 1,190, the minimum 1,020 c.c. (cat. no. 137).

These crania are normal in every respect except in point of size. A few of them have been subjected to Aymara deformation. The smallest one of the series, an adult female cranium from Paucarcancha (cat. no. 137), is reproduced in Plate XVII. There is a barely perceptible suggestion of Aymara deformation. Of the 16 upper teeth 13 were present at the time of decease. Only two teeth are still in situ; the crown of one of these has disappeared through decay and there is a large bone cist at its root. The orbits are quadrangular and droop or slant downwards toward the sides to an unusual degree. It has not been possible to fit a lower jaw to this cranium. However several of the small crania in the series are accompanied by their lower jaws and these do not differ in form from those of somewhat larger size.

In the odd lot of unfitted lower jaws from Paucarcancha there is one (cat. no. 194) that merits special attention (Pl. XVIII). Although unusually small and narrow, it is of very robust build. The bicondylar breadth (10 cm.) is too small for even the smallest cranium in the collection; and yet the minimum breadth of the ascending ramus is as large as the largest ascending ramus in the entire collection (3.7 cm.). In fact only three other lower jaws, all of them belonging to males, approach it in this respect. The ascending ramus is also remarkable for the straightness of its anterior margin. In the collection taken as a whole, the coronoid process is almost without exception higher than the condyloid. In this specimen the reverse is the case and the sigmoid notch is very

shallow. The bigoniac diameter measures only 7.1 cm. There are sixteen teeth, all of which were in situ at the time of decease and only one of which shows any sign of decay. The third molars are well developed and only slightly worn. The mental spine is but feebly developed. The delimitation of the area for the attachment of the masseter muscle is marked by a pronounced bulge on the outer face of the horizontal ramus. In view of its robuscity the lower jaw is evidently that of a male, and of an individual some 40 years old, judged by the worn crowns of the first molars.

The nearest approach to the lower jaw just described is seen in another odd lot of specimens, also from Paucarcancha (cat. no. 927). It however lacks the left ascending remus. On the right side, the coronoid process is 1 mm. higher than the condyloid process. In all respects this jaw is less robust than the previous example and probably represents a female of the same type. All sixteen teeth were present at the time of decease and eleven are still in place. The wearing of the teeth indicates an age of about 30 years. The third molars are as large as the others. The teeth are all sound with the exception of a small cavity in the second right molar. The socket of the left third molar had been attacked by pyorrhea alveolaris. The mental spine is no better developed than in the Neandertal jaws of paleolithic Europe.

It is unfortunate that the Expedition was unable to recover the crania belonging with these two lower jaws, and even more unfortunate that at least one entire skeleton was not discovered. There are however among the odd-lot long bones in the collection the arm bones of a small but remarkably robust individual. These likewise are from Paucarcancha and belong to a small stocky male comparable in size and build with the one to which the lower jaw just described must have belonged. That the arm bones and lower jaw belong to one and the same individual however is hardly possible because of the differences in their present condition. The lower jaw is completely cured and stained a uniform ruddy brown; it had evidently been buried a long time. On the other hand, the arm bones have lost none of the original color; moreover shreds of the periosteum are distributed over the surface of all four bones. They represent one of the latest burials in the cave.

The two humeri of this skeleton are thick and heavy in proportion to their length. The surfaces for the attachment of muscles are rugged. This is especially true of the ridge for the insertion of the pectoralis major and for the external head of the triceps. The adjoining grooves are correspondingly deep. The caput is large and the epicondylar

breadth great. The maximum humeral length for the right is 25.3 cm. and for the left, 24.7 cm. (Pl. XIX); cat. no. 299.

The maximum length of the radius is 18.6 cm., as compared with a range of from 19.0 to 28.8 cm. in medium-height to tall races. The articulated extremities are relatively large and the shaft thick. The interosseous crest is especially well developed. The interosseous crest of the ulna is also very pronounced. The maximum ulnar length is 20.6 cm. as compared with a range of from 21.5 to 30.5 cm. for medium height and tall races. The ratio of the upper arm length to the fore-arm length, or the radio-humeral index, is 73.8. The fore-arm therefore is short in comparison with the upper arm and the individual would be classed as brachykerkic according to Turner's grouping.*

Among the pelves there is one of an adult female which is of small size. It also is from Paucarcancha (cat. no. 439). Except in point of size it is a perfectly normal pelvis. The female characters are well marked, especially so in case of the pre-auricular grooves which are unusually broad and deep. The bones of this pelvis are light of build even for the female sex.

The evidence in favor of a "pygmy race" in the Peruvian Highlands is thus seen to be quite insufficient for any important conclusions. There were small individuals with small skulls, but there is no proof that they were not mere variants of the general population.[1]

SURGERY

Our knowledge of prehistoric surgery is limited to operations that affected the bony tissue. The osseous remains of paleolithic man thus far brought to light are relatively few in number; hence the small chance of discovering traces of paleolithic surgical operations even if these existed. On the other hand there is abundant evidence that neolithic man practiced surgery with a considerable degree of skill and

Dolichokerkic, 80 and above; *mesatikerkic*, 79.9 to 75; *brachykerkic*, below 75.

[1]Hrdlička, who in 1910 and 1913 collected approximately 3,600 crania on the coast and in the mountains of Peru, has found in this material, which is now deposited in the U. S. National Museum, 26 non-pathological female skulls, with two possibly male crania, whose capacity ranges from 910 to 1050 cc. These specimens constitute simply the lower end of the curve of variation of cranial capacity in the whole series, show no disturbance of this curve, and agree in every important other feature with the skulls of higher capacity so that they may safely be regarded as belonging to the group, and as being mere variants in size of the Peruvian type of skull, offering no indication of an admixture of a separate strain of people. In Hrdlička's opinion there is no trace in Peru, or elsewhere in America, of any separate race of "Pygmies"

success. One of the best known and most remarkable of neolithic surgical operations was trepanation. It can be traced without a break from modern surgical practice back at least to early neolithic times and to a race akin to the paleolithic hunters of western Europe. Its antiquity is matched by the boldness which led to its inception. The hardihood of the first attempt could scarcely have found sufficient basis in a knowledge of cephalic anatomy; and yet those who deposited their dead in communal sepultures must have been more or less familiar with the human skull. Given a great emergency, this slight familiarity might have contributed toward a steadiness of hand and nerve not otherwise attainable. The first cases might well have been victims of accident. This was the view of Prunières,* who supposed that once a depressed fracture had been successfully relieved, a like operation might be tried on those suffering from delirium or convulsions not due to violence but with symptoms similar to those caused by a depressed fracture. On the other hand, in the opinion of Broca,* such a view would presuppose physiologic and medical knowledge not within the reach of the neolithic practitioner. The latter he believed to have been inspired by superstition rather than by observation. Two of Broca's reasons for this conclusion were what he believed to be the complete absence of any vestige of antemortem fractures about the trephined area; and the constant integrity of the forehead which would not have been respected by fractures. We shall see however that in so far as Inca trepanation was concerned, Broca was mistaken on both these points. The number of exceptions to what Broca believed to be the rule would doubtless be larger were it not for the fact that in a majority of traumatic cases the signs of fracture would be entirely removed by the operation.

A point in support of Broca's theory was the presence of cranial bone amulets in French neolithic sepultures, especially those of the Lozère and the Marne. Superstition is rooted in the unknown. Mysterious maladies, whose causes were attributed to divine or diabolic influences, are those most likely to give birth to such a practice as trepanation. Among these maladies epilepsy and convulsions of every sort would naturally take first rank. The occasionally great strength of the patient during an attack was proof of the presence of an imprisoned Spirit. Release this Spirit and the malady would be cured, hence the trepanation.

The neolithic operator did not distinguish between epilepsy and con-

*_Congrès de Lille_, 1874, p. 626.

*_Congr. Intern. Anthr. Arch. préhs._, Budapest, 1876, 163.

vulsions common to childhood. The failures to cure epileptic cases by means of trepanation would be offset by the cases of childhood convulsions which would be outgrown. The practice would thus be justified and become fixed. In time special virtues might be attributed to crania that had been trephined. The aperture through which the Spirit escaped would come to possess supernatural qualities; from its borders would be (in fact were) cut bone amulets to be worn by those who would escape similar maladies. In time also might incomplete trepanation, i. e. the removal of the external table, be substituted for the more serious operation involving the entire thickness of the cranial case. All these points are discussed in the literature of the subject.

That flint implements were wholly adequate for the operation was demonstrated by Broca,* who by means of a paleolithic chipped flint from the cave of Cro-Magnon (Dordogne) trephined the skull of a two-months old dog. The operation, which was by the scraping process, lasted eight minutes; during which time the dura mater was laid bare over an area as large as a 20 centime piece. Broca was able also to satisfy himself that scraping subjected the outer cerebral membrane to less danger than any other trephining process. The dog did not even have a temperature following the operation and the wound healed promptly, this despite the fact that the flint was of great antiquity and somewhat dull instead of possessing the keen edge produced by a fresh fracture of freshly quarried flint.

It is not strange that even the best authorities should have confounded, for a time at least, cases of prehistoric trephining with openings which might have been the direct result of wounds or of pathological conditions. Again some openings in the cranium are known to be congenital.* To the latter category belong the abnormally large parietal foramina and some pathological or teratological defects. But their position and nature make them easily distinguishable from trepanation. Pathologic openings in the skull are produced on the one hand by intra- or extra-cranial tumors that invade and destroy the bony tissue; on the other hand by a disease of the bone istelf. The former need not be confused with trepanation, because the margins cannot cicatrize. In the latter, although cicatrization is possible, the diseased condition of the bone extends beyond the margin of the perforation.

Traumatic openings would be the most difficult of all to distinguish from trepanation, because there might be complete cicatrization of the

Bull. Soc. Anthr. Paris, 1877, 400.

*Broca, *Bull. Soc. Anthr.* Paris, 1885, 192–198, and 326–336.

margins and at the same time complete integrity of the adjoining bony tissue. Hence the appearance of a key specimen was necessary in order that the scientific world might grasp the fact of prehistoric trephining.

It remained for a noted American archaeologist, E. G. Squier, to produce the key specimen. In examining the important collection in the palatial residence of Senora Zentino of Cuzco, Squier's attention was attracted by a skull from a pre-Columbian Inca cemetery in the Yucay valley, twenty-four miles east of Cuzco, the cemetery being within a mile of the 'Baths of the Incas.' This skull[1] was given by his hostess to Squier, who later submitted it to Broca. The latter immediately recognized the skull as a case of trepanation,[2] for the simple reason that the opening could not have been due to any other procedure.

The aperture is rectangular and produced by means of two pairs of parallel incisions, one pair at right angles to the other. Since the incisions extended in all directions beyond the corners of the opening, this method necessitated the removal of relatively much more periosteum than would be required in the more complex circular operations. Curiously enough Broca failed to profit fully by the lesson of this case from Peru; for it was not until several years later that he recognized as actual cases of trepanation the prehistoric examples already found in France.

Perhaps in no other part of the world was prehistoric trepanation more in vogue than in Peru. The geographic distribution of the practice in Peru is quite general with the exception of the coast region. In the Muñiz collection described by McGee,[3] comprising a total of nineteen trephined crania (eleven being from the province of Huarochiri), fourteen were from west central Peru and the more arid piedmont and coastal region, while five were found in the vicinity of Cuzco. These were culled from a general collection of 1,000 skulls.

Dr. Julio C. Tello[4] figures twenty-four trephined skulls of the ancient Yauyos, who occupied the same general region as the Huarochiris. It was this region in the foothills to the east of Lima that furnished eleven of the trephined crania in the Muñiz collection. Tello states that in general some 10,000 crania and mummies were taken from the caverns and low stone structures (*chaukallas*) of the locality in question. The

[1]Now in the American Museum of Natural History, New York City.

[2]Cas singulier de trépanation chez les Incas. *Bull. Soc. Anthr.* Paris, 1867, 403.

[3]Manuel A. Muñiz and W. J. McGee. Primitive Trephining in Peru. XVI *Rep. Bur. Amer. Ethnol.*, 11–72, Washington, 1897.

[4]Prehistoric trephining among the Yauyos of Peru. *Proc. Intern. Congr. Americanists.* London, 1913, Part 1, 75–83.

earlier Tello collection of trephined crania now belongs to the Warren Museum of the Harvard Medical School. In this zone the Aymara language has not yet even been wholly supplanted by the Quichua language, which surrounds it "and which the Incas made every effort to spread."

In the Tello collection there are seven pronounced examples of the rectilineal mode of operation as typified in the Squier specimen previously described. In the Muñiz collection there are five such examples, four being from Huarochiri, which therefore might be looked upon as a center for this primitive type of operation.

McGee and Tello differ as to the motives which led the ancient Peruvians to practice trepanation. According to McGee, there are suggestions of therapeutic treatment in a few of the crania; but stronger indications that even in these cases, the operations were primarily thaumaturgic; while in the great majority of cases the operations can only be interpreted as wholly thaumaturgic. Moreover he minimized the skill of the practitioner and believed the percentage of successful operations to be very low.

On the other hand Hrdlička, who in 1913 brought a large collection (over 80 specimens, as yet undescribed) of trephined crania from Peru to the U. S. National Museum, has been able to satisfy himself that the operation in a large majority of cases was a true surgical measure, employed in cases of cranial lesions due to injuries of various natures. Tello taught also that trepanation was preeminently a therapeutic measure employed in cases of 1) an antecedent fracture; 2) a simple traumatism of the cranium which denuded the periosteum; 3) a circumscribed periostitis perhaps also of traumatic origin; 4) lesions, probably of a syphilitic nature. He was also impressed by the skill of the operator as well as by the dgeree of success attained. In the Yale-Peruvian collection about to be described, there is evidence in support of the views of both McGee and Hrdlička with Tello (excepting syphilic).

While the examples described by McGee and Tello have many points in common with those in the Yale-Peruvian collection, one is struck by the complete absence in the latter of trepanations by means of two pairs of straight incisions. In this collection as in all collections of the kind, it has been practically impossible to distinguish in certain cases between trepanation and scars or artificial apertures in the cranium due to other causes. In reporting our cases we shall therefore begin with undoubted examples that still bear distinct marks of the surgeon's instrument, and pass by degrees to the doubtful cases. The relatively high percentage of examples in which the brain case has been attacked in one way or another

leads one to the conclusion that whether in sickness or in health, in peace or in war, the ancient Peruvians of the Highlands were a cephalo-centric race.

The first example is that of a female about twenty-four years of age from Paucarcancha (Pl. XX, no. 1). There is a crudely cut circular opening nearly midway between the sagittal suture and the left parietal eminence. Marks of the primitve instrument are distinctly visible on the surface of the bone along and near the margin. The cranial wall is thick (nearly 7 mm.). The surrounding bone was in a perfectly healthy state. No radiating fissures are visible; but there is a distinct fissure in the plane of the diploe. The operation was evidently to relieve the effects of a severe blow and was followed by the death of the victim before the healing process had become manifest in the bone. The blow of itself might have been fatal. The fact that the patient did not survive is no reflection therefore on the operator.

The second example is that of an adult male about twenty-four years old, who had been subjected to a slight Aymara deformation (Pl. XX). The trephining operation was undertaken to relieve a formidable depressed fracture affecting both the frontal and left parietal, with its center in the region of the stephanion. The large irregular aperture has a total length of 8.4 cm. and a maximum width of 5.0 cm. In addition the external table has been removed over a field extending from the left supra-orbital margin to the anterior margin of the large aperture. Surrounding the aperture (except for a short stretch at the posterior end) and roughly parallel to its margin, there is a distinct ring marking the limits to which the periosteum had been laid bare. A fissure passes from the anterior end of the opening to and across the supra-orbital ridge; a similar fissure, or the continuation of the same one, extends from the posterior limit of the opening almost tothe left lambdoid suture. Further proof of the fracture is to be seen in the undercut margin of the aperture in the frontal region. In this case the instrument employed was much sharper than in the preceding. The margins, especially at the rear, are so clean cut as to suggest the use of a steel blade. If this be so, then Paucarcancha must have continued to serve as a place of burial after the arrival of the European.[1] The bone did not heal; the case was desperate and would probably have been lost even by the best modern surgeon.

An oval aperture large enough to admit the passage of the forefinger

[1]For survival of the practice among the Indians of Bolivia and Peru to this day, see Bandelier, (Adolph H.), *Am. Anthrop.*, 1904, VI, 440–6.

passes somewhat slantingly through the right parietal eminence of a fragmentary adult female skull (Pl. XX). The margin, especially in the external table, is very smooth as if it had undergone the process of healing to some extent, but the surface of the thick diploe remains as spongy as when first cut. There is nothing to indicate an antecedent wound or disease of the bone.

A female skull with Aymara deformation has a circular aperture 66 mm. in diameter located in the posterior region of the right parietal and slightly encroaching upon the left parietal in the region of the obelion (Pl. XX). Unfortunately the posterior third of the rim has been removed through decay. The margins are fresh and somewhat rudely cut. If the operation was performed to relieve the effects of a wound, all signs of the latter were carried away by the operation.

In a youthful male of about twenty years, with Aymara deformation, there is an oval opening 4.8 by 3.5 cm. in the right parietal, reaching from the coronal suture almost to the parietal eminence (Pls. III, XXIV). Although no terminal fissures radiate from the opening, the undercutting and nature of the upper margin of the opening would seem to point to a depressed fracture as the cause of the operation. Marks of the instrument are distinctly visible along and near the margins. The bone had not healed when death supervened. This might have been due more to the antecedent wound than to any lack of skill on the part of the surgeon.

There is a nearly circular opening with a mean diameter of 27 mm. midway between the right parietal eminence and the sagittal suture of an adult male 30 years old (Pl. XXV). The thickness of the brain case at this point is about 9 mm. The slightly projecting internal table would have made a good rest for a plate of some sort. The healing of the bone had not gone far, since one can still detect marginal scratches caused by the instrument. The effects of inflamation presumably caused by the operation cover a crescent-shaped strip along one-third of the margin. The motive for the operation is not evident.

The next three examples are from Patallacta. An adult female of about 28 years suffered a severe fracture of the skull reaching from the right ala magna of the sphenoid to the left parietal eminence, and from a point in front of this eminence by way of the bregma to the right spheno-parietal suture (Pl. XXVI). Coincident with the fracture, the first right molar was split open and a portion of the crown lost. The lower jaw not having been recovered, it is impossible to state whether any of the lower teeth suffered from the shock. To relieve the fracture

of the skull, two operations were performed: 1) An irregular piece of bone 3.6 by 2.6 cm. was removed from the track of the fracture midway between the coronal suture and parietal eminence. The front half of the margin is cut smooth by the surgeon's instrument. 2) A spindle-shaped piece of bone 4.7 by 1.4 cm. was removed from the frontal in the region of the bregma. Here again only the front half of the margin has been cut by the surgeon, marks of his instrument being carried over on to the parietals at each end of the aperture. The posterior margin of the opening coincides throughout with the coronal suture. The instrument employed was not only very sharp but also under perfect control. The violence of the shock that caused the fracture however was too great a handicap for the skill of the surgeon to overcome and death followed shortly. In this case the motive cannot be covered by any cloak of mystery. The operator simply risked a chance to relieve an unfortunate victim of accident or violence and lost.

The skull of an adult male about 55 years old is reproduced in Pl. XXVI. The oblong aperture 35 by 15 mm. in the left parietal just above the level of the obelion coincides with the area of a depressed fracture that proved fatal almost immediately. The surgeon's knife was used only to smooth a portion of the margin of the external table and left a few slight scratches just beyond the margin. This skull also carries two large scars. One of these is near the left frontal tuber; the other is in the right parietal just back of the stephanion. Both are probably the result of accident or violence; although trephining operations that affected only the external table might leave similar scars.

The skull of another male about 55 years old, has a roughly circular aperture 3.0 cm. in diameter in the frontal directly above the left zygomatic process (Pl. XXVI). A fissure extends from the anterior margin of this aperture to the roof of the orbit. However to conclude from this that the trepanation was to relieve a fracture would be uncertain in view of the fragmentary condition of the skull. Judging from the condition of the margins, death must have ensued very soon after the operation, which would be to say the least negative evidence in favor of an antecedent fracture. Just back of the left parietal tuberosity, the external table has been removed over an oval area 18 by 11 mm. This might have resulted from the glancing blow of a sharp weapon; or it might have been a minor trepanation. In either case it was done at about the same time as the operation on the frontal, or as the antecedent fracture if there was one. In the latter case it would be logical to assume that the fracture and the wound on the parietal were both received

in conflict and that immediately thereafter recourse was had to an operation.

Torontoy has furnished two specimens in which the motive for the operation is unmistakable. The skull reproduced in Pl. XXVII, is that of a male about 28 years old. The large opening 7.3 by 5.8 cm. made at the expense of the frontal, left parietal, temporal, and wing of the sphenoid, is a typical example of primitive trephining. In places the inner table is left projecting into the aperture as if the surgeon had found difficulty in removing this table without injury to the cerebral membranes. Beyond the ragged margins are numerous tangential incisions, some of them at least 3 cm. in length. The patient had previously suffered a bad fracture of the temple, the results of which can still be seen in two radiating fissures. One of these extends from the lower anterior margin of the aperture across the left zygomatic process of the frontal and roof of the orbit; the other from the lower posterior margin downward and backward across the temporal to the base of the mastoid process. The absence of healing is proof that the subject was unable to withstand the combined shock due to the blow that caused the fracture and to the trepanation, the latter made doubly long and painful through the use of a stone instrument.

The second skull shown in Pl. XXVII is from a mummy (Pl. V). The sex of the skull alone would have been difficult to determine, but the pelvis is that of a female; the age is about 30. An opening 4.5 by 4.0 cm. extends from the right stephanion almost to the bregma. Marks of the instrument are distinctly visible, proving that the patient died shortly after the operation. The surrounding bone had been honeycombed by disease prior to the operation; the grounds for the latter were therefore therapeutic.

The last skull in this series is an adult male about 50, belonging to one of the mummies found in cave number 11 at Huata (Pl. XXVII). A depressed fracture midway between the orphryon and bregma was relieved by the surgeon, the marks of whose instrument are visible along the entire left margin of an aperture, 3.8 by 2.0 cm. in dimensions. The patient however, did not survive. From this same cave another trepanned skull was taken (Cat. no. 887).

We shall now consider a series of cases in which the healing process has removed all traces of the surgeon's instrument, but which are obviously examples of trepanation.

An adult female about 36 years of age with pronounced Aymara deformation has undergone trepanation at two distinct times (Pl. XXVII).

The first was between the obelion and the left parietal tuber, the other between the obelion and the right parietal tuber. The two are thus placed so as to be bilaterally symmetrical. In each the field covered was approximately the same, each being nearly round with a diameter of about 3.8 cm. The earlier operation, on the left, had entirely healed; near the center of the scar is a tiny hole with sloping walls. The operation on the right, which was followed by a partial healing, seems to have been performed by scraping, the surface being left practically flat in one direction and slightly cupped in the other; at the center a small pit just falls short of penetrating the internal table and is comparable with the hole on the opposite side. The sameness of the two operations and their symmetrical arrangement precludes the possibility of their having been due to chance wounds inflicted either intentionally or unintentionally. They are just as much trepanations as those in which the regenerative process had not yet obliterated the tell-tale marks and fortuitous supplementary incisions of the surgeon's instrument. The motive for the operations is hidden. In another adult skull with pronounced Aymara deformation (cat. no. 29), there is precisely the same operation and in the same position, but it was performed on the right side only. The skull is fragmentary, but the field of the operation was intact when this study was made. If this latter example stood alone, there might be some doubt as to the validity of the interpretation here given, but taken in connection with the skull shown in figure 4, Pl. XXVII, there can be no reasonable doubt. Both are from Paucarcancha.

The cranium seen in Pl. XXVIII is that of a male about 28 years old. It has been subjected to a slight Aymara deformation. It has a large circular opening 4.1 cm. in diameter in the left parietal almost immediately back of the eminence. The external table however has been removed over a much larger area, suggesting that the operation was effected through scraping. The aperture was covered by mummified skin when the specimen came into the hands of the author. This is proof sufficient that the ancient Peruvian practitioner was able to carry out a trephining operation on a large scale without fatal results. If the motive was to remove diseased bone or to relieve a fracture, all traces of the cause were obliterated by the operation. The cause may have been deeper seated than the cranial wall. Erdis states, as already mentioned, than a rabbit mummy (guinea pig according to Dr. Eaton) was found at the mouth of this skull, which with some of the mummy wrappings was found in the big cave at Paucarcancha.

In another skull figured on Pl. XXVIII, representing an adult male

of about 65 years of age, an oblong opening 2.4 by 1.5 cm. is situated between the right frontal tuber and the stephanion. The walls are sloping so that the passage through the outer table is larger than that through the inner. Bony spicules from the latter project into the opening. Directly above this aperture there is a large cicatrice 3.1 by 2.5 cm. in dimensions. Another somewhat smaller oval cicatrice is on the left frontal eminence. Both these are probably the result of wounds.

We come next to what is manifestly the most remarkable case on record, an adult male of about 65 years from Patallacta (Pl. XXI, upper two figures). This man underwent as many as five trephining operations all of which penetrated to the cerebral membranes and which were apparently performed at various times. In only one of the five is there any distinct indication of infection. Did the surgeons of that time possess any effective means of combatting septicemia? It would seem so; especially in view of the fact that the Incas were on occasions successful embalmers of their dead. Recently Reutter[1] has made an analysis of embalming substances from Peru. These were found to contain *Baume de Peróu*, menthol, salt, tannin, alcaloids, *saponines* and undetermined resins. Like the ancient Egyptians and Carthaginians therefore, the Incas made use of substances rich in "*acide cinnamique*" to embalm their dead. As these have excellent antispetic properties, it is permissible to presume that the surgeons of time have taken advantage of their therapeutic value in trephining operations.

Cushing[2] describes the operation on a gangrenous wound in the foot of an Indian. After cleansing the tumor, it was cut open; pus, serum, and gangrenous tissue were removed, and the discolored periosteum carefully scraped (the lancets were of bottle glass and obsidian). At this stage a fetish was ceremoniously applied to the affected spot for a moment, after which the wound was repeatedly cleansed, sprayed with an infusion of willow-root bark, and dried. Finally came the application of piñon gum and a neat bandage, the dressing being dusted with an astringent powder. McGee justly calls attention to the probability that the primitive surgeon might give to the fetish the credit due to the after treatment. Incantation might well have been an accompaniment of ancient Peruvian trepanation; there is no positive proof to the contrary. There does however seem to be proof that something more than magic was necessary in order to obtain such results as are afforded in the present specimen.

[1] *Bull. Mém. Soc. Anthr.* Paris, 1915, VI, 288–293.
[2] A case of primitive surgery, *Science*, 1897, n. s. V.

All five of the apertures are nearly round and vary but little in size (about 3.2 cm. in diameter). Two of these are on the left side of the frontal and so close together that only a slender bridge of bone intervenes. Had the two operations been performed at the same time there would have been either no bridge at all, or else a more substantial one. The upper of the two is probably the later operation. The third aperture is midway between bregma and obelion, its center being a little to the right of the sagittal suture. The fourth and fifth openings are wholly within the right parietal, one being between the third and the eminence and the other between the eminence and the obelion. This was probably the latest of the five operations and is the one that was followed by infection. The external table has been removed from two oval spots on this skull, one near the right frontal tuber and the other near the left parietal tuber. Whether these represent minor trephining operations it would be difficult to say. Even if they do not, the skull would still be secure in its title to rank first in its class. This skull, with no signs of local pathological conditions and with nothing to indicate a single case of fracture, is one of the weightiest known documents in favor of trepanation for troubles that do not have their seat in the bony framework of the head. It also shows that trepanation was performed on the forehead as well as those regions generally covered by the hair. The bone had thoroughly healed after each of the five operations.

In Pl. XXVIII is also a view of an adult male skull from Patallacta. The age was approximately 24 years. On the frontal near the bregma the external table has been removed over an area with a mean diameter of about 4.4 cm. The aperture as it passes through the internal table is only 2.7 by 2.0 cm. and has a jagged margin. Trepanation here was obviously effected by means of scraping. Immediately above the brow ridge and just to the left of a median plane is another smaller aperture, which at the level of the internal table is only 9 by 5 mm., but which called for a much greater sacrifice of the external table and diploe. The general aspect of this aperture and of the bone below it including the left brow ridge and roof of the orbit on the same side leads one to the supposition that this region had been the seat of pathological trouble. The aperture might have been produced by an operation that was followed by infection; it might have been produced by a wound followed by infection; or by a tumor. The bridge of the nose had been broken and bent to the right, but had healed.

Another good example of forehead trepanation is seen in the fourth figure of Pl. XXVIII representing the skull of a male about 80 years old.

In this case however, there is the remnant of a small radiating fissure, as if the operation had followed a fracture; the surgeon therefore had no other choice but to open a hole in the forehead. The external table was removed from an area 3.5 by 3.4 cm. situated over the right brow ridge; but on account of the sloping walls the opening through the inner table is only 2.8 by 2.3 cm. Between the right parietal eminence and the obelion are two small shallow circular pits that expose the diploe. Are these minor trepanations? It would be difficult to say. The process of regeneration had not proceeded far enough to obscure the spongy nature of the diploe whatever might have been the cause of the lesions.

The two ends of the suture separating the Inca bone from the rest of the occipital still persist in the skull of a male about 60 years old (Pl. XXIX). The trepanation took place within the right half of this Inca bone. The external table was removed over an oblong area 4.0 by 2.5 cm. while the irregular opening through the internal table is only 2.3 by 1.0 cm. The contour of the skull in this place is such that the loss of bony tissue could not have been due to the glancing blow of a sharp weapon. There is no sign of fracture or local disease of the bone.

The skull of a male about 50 years old reproduced in another figure of Pl. XXIX, is from Patallacta. The oval aperture, 5.0 by 4.1 cm., in the region of the left parietal tuber, is the combined result of a depressed fracture followed by an operation. The only visible evidence of a fracture is the undercutting along the lower anterior third of the margin. Outside the remaining two-thirds of the margin, the external table was removed from a narrow strip as a part of the surgical operation.

The forehead is the seat of operation in two other skulls from Patallacta (Pl. XXIX), and in neither is there any trace of an antecedent fracture. The first is of an adult male about 55 years old with Aymara deformation. The oblong aperture with sloping walls is immediately above the right superciliary arch. The perforation higher up in the frontal is post-mortem. In the second case, that of an adult female about 60 years old, there is an oval aperature in the region of the left frontal tuber. Infection seems to have followed the operation, but did not spread equally in all directions from the margins of the opening. These two examples add further confirmation to the view that the forehead was not a privileged area in the eyes of the ancient Peruvians practitioner and was not spared an operation in the event of fracture or perhaps some disease of the bone.

The skull of a large and powerful male about 55 years old is reproduced in plate XXI, the two lower figures. It is from cave number 9 at Huata,

described as an open cave on a point east of the houses and about 50 feet below them. The skull presents a variety of phenomena. In the first place there are two trepanations near the vertex—one in the right half of the frontal near the coronal suture and one in the upper anterior angle of the right parietal. In each the loss of the external table far exceeds that of the internal table. The margin of the latter in the larger of the two openings is dentate. In neither case is there any evidence of antecedent fracture or disease of the bone. On the occipital near the lambda and in contact with the left branch of the lambdoid suture, the external table has been removed, apparently by scraping, from an oval area 4.0 by 2.5 cm. Near its center is an irregular pit that reaches to the internal table but does not penetrate it. The operation therefore might have combined cauterization with scraping; it was probably subsequent to the two trepanations in the vertex, although the healing of the bone is well advanced.

In the frontal a short distance above the right brow ridge is a small irregular aperture that might have been due to violence; the bone is thoroughly healed. Farther up on the frontal and just to the left of a median plane is a deep pit causing a dent in the internal table but not penetrating it. Although the surface of the pit is irregular, the healing process is complete. It might have been caused by a heavy blow (the skull is thick). There is another deep elongated dent extending across the left fronto-zygomatic suture due to violence, the blow carrying with it a portion of the fronto-sphenoidal process which now projects into the left orbit. The base of the left temporal crest was also split by the same blow or by another less violent. The skull thus bears the scars of no less than seven encounters with enemy and with surgeon none of which proved fatal. That its owner also had his share of dental suffering, the large bone cist connecting with the socket of the upper right median incisor bears abundant testimony.

From cave number 10 at Huata two trepanned skulls were taken. Both had been subjected to Aymara deformation. The one reproduced in plate XXX, is of an adult male about 35 years old. The trepanation at the expense of both occipital and left parietal lies across the track of the lambdoid suture nearly midway between the lambda and the left asterion. The operation was evidently performed by means of scraping as it affected the external table over a much larger field than it did the internal; the margins of the latter are irregular. There is nothing to indicate that the operation was for the purpose of removing diseased bone or relieving a fracture. The other skull from this open cave is that

of a male about 45 years old but it is so badly weathered that it is not reproduced. The circular aperture 38 mm. in diameter is in the right parietal midway between the eminence and the sagittal suture.

Another skull in this series, that of an adult male about 50 years old, with Aymara deformation, is from cave number 11 at Huata (Pl. XXX). The external table has been removed from a circular field 1.7 cm. in diameter midway between the left parietal eminence and the lambdoid suture. The hole through the internal table is not much larger than the head of a pin. On the frontal just above the left eminence is a trepanation by scraping affecting only the external table in a field 2.3 by 1.1 cm. The healing process though well advanced has not completely effaced the cellular character of the diploe. We have in this skull another battle-scarred veteran whose left cheek had been battered in and nose broken but who had fully recovered from his wounds.

The skull of a small adult male about 25 years old shown in Pl. XXX, was taken from the surface of an open cave (grave no. 2) at Yanamanchi and is so weathered that it would be difficult to say whether or not the bone had healed after the operation; this involves an oval area 6 by 5.2 cm. in the frontal and reaching down to the right brow ridge. Two fissures radiating from the lower half of the aperture are in all probability the result of a fracture which would seem to be the only sufficient cause for such an extended mutilation of the forehead.

We shall next consider a large group of cases in which some are presumably trepanations, while others must be classed as more or less doubtful. The left lower skull in Pl. XXIX is of a male about 60 years old. On the right half of the frontal near the coronal suture, the external table has been removed from a field 2.2 by 1.5 cm. apparently by scraping. The place had healed although the pores of the diploe are not wholly obliterated. It is probably a case of minor trepanation.

In the skull shown in the upper left figure of Pl. XXXI, the small aperture in front of the left parietal eminence was probably the result of trepanation. The bone had thoroughly healed and there is no sign of an antecedent fracture. The skull which had been subjected to Aymara deformation, is that of a female some 40 years old.

In the right upper figure of Pl. XXXI, the cicatrice is one that might have developed from a wound caused by the glancing blow of a sharp weapon, such for example as a sabre might make. It is one of many such. In a fragmentary male cranium also from Paucarcancha (cat. no. 67), the external table is removed in a clean-cut manner from a field 4 by 3.7 cm. in the region of the right parietal tuber. As however no

sabres have been reported from these caves, the most plausible explanation would be trepanation by scraping. We know that during the neolithic period and later in Europe trephining was done not only by this process but also by cauterization. There is reason to believe that both these methods were practiced among the ancient Peruvians as we shall presently see. The case before us is almost certainly an example. The external table had been removed from a circular field 4.3 cm. in diameter at the expense of right parietal and frontal. The skull is of a youth about 20 years old.

The weight of evidence furnished by the cranium shown in the left lower figure, Pl. XXXI, is against trepanation. The rugose cicatrice some 2.7 cm. in diameter midway between the left parietal eminence and the sagittal suture does not have a single earmark of trepanation. The bony tissue is altered through suppuration but none of it seems to have been cut away. Loss of the external table however leaving a scar 2.5 by 1.6 cm. is to be noted in the right parietal near the obelion and lambda. It looks more like a case of cauterization than of scraping or cutting; and yet it might have been due to some wholly different cause. It must remain therefore in the doubtful column.

An oval cicatrice with a maximum diameter of 4.5 cm., not unlike one that might have been the result of a sabre stroke, is in the left parietal near the sagittal suture and midway between the coronal and lambdoid sutures of the skull of a male about 30 years old with Aymara deformation (right lower figure, Pl. XXXI). The inner table was penetrated leaving a hole 7 by 3 mm. The scar is slightly dished in the direction of its shorter axis, which gives it all the more the appearance of having been caused by a saber stroke; and yet I am inclined to give it a place in the trepanation column.

The skull of a female some 40 years old, also with Aymara deformation, is reproduced in the upper left figure of Pl. XXXII. The oval scar (2.8 by 2.1 cm.), on the right half of the frontal near the coronal suture was probably caused by something other than trepanation. This belongs to a complete mummy, about whose waist was found a piece of knotted red cord.

There is a large cicatrice some 60 by 30 mm., affecting the left parietal and impinging to a smaller extent upon the frontal of a male about 40 years old (right upper fig., Pl. XXXII). The surface is irregular with a pronounced pit near the center. This is another of the doubtful cases, although just such a scar might result from cauterization. The Aymara deformation is barely perceptible.

The case of a female about 38 (upper left Pl. XXII) is less doubtful. The external table has been removed from an oval area 5.8 by 4.4 cm., affecting for the most part the frontal, but also the right parietal to some extent. All available evidence is in favor of trepanation by scraping or cauterization. Although the healing is well advanced, the diploe is visible over the inner half of the field.

The skull of a female some 60 years old is reproduced in plate XXII (right lower). Below and back of the left parietal eminence the external table has been removed from a round field 2.6 cm., in diameter. The regenerative process had not proceded far enough to completely fill the pores of the diploe. Here again a glancing blow from a sharp weapon might produce such a result, but why should so many of the women of the Peruvian highlands have been subjected to blows of this kind. It would be more logical to assume this to be a case of trepanation, the motive being thaumaturgic.

In the skull of a female about 22 years old from Paucarcancha there is a deep oblong cicatrice overlapping almost equally on the left parietal and occipital near the lambda (left lower, Pl. XXII). Whether the external table has been removed by an operation or the entire thickness of the cranial wall was simply carried in by the impact of a blow it would be difficult to say. The indentation of the inner table at this point favors the latter view as does the suggestion of a fissure extending beyond the upper margin of the part affected.

Near the lower anterior angle of the right parietal in the skull of a male some 65 years old, there is a perforation large enough for the passage of a knitting needle (left lower, Pl. XXXII). Whether this be natural or artificial it would be impossible to say. Near the center of the left parietal of a skull from Patallacta (cat. no. 646), there is a small pit with clear-cut perpendicular margins which has the appearance of being artificial. It falls just short of penetrating the inner table.

The deep oblong cicatrice on the left zygomatic processs of the frontal reproduced in plate XXII, right upper figure, is another one of the doubtful cases. The raised scar above the right brow ridge and near the metopic suture is typical of the extent to which in this district the head has been attacked in one way or another. The skull is that of a small male who had reached the age of some 60 years.

That the aperture 21 by 8 mm., below the left parietal eminence of a youth about 20 years old was caused by trepanation, there can be little if any doubt (right lower fig., Pl. XXXII). The edges of the internal table were left sharp and jagged in the healing. The external table was

removed over a much larger area (3.3 by 3.0 cm.). The motive for the operation was apparently thaumaturgic, since the bone is not diseased and there is no trace of antecedent fracture. The head had been subjected to Aymara deformation. The atlas is fused with the occipital and there is a well-developed processus marginalis on the malar bone, even more pronounced on the right side than on the one seen in the figure. The skull came from the cave in a mumified condition. Erdis states that when found, this skull "had rope over head and around neck."

Nature unaided and unhampered can alone do much; assisted even by primitive intelligence, she can do more. Her recuperative powers are well illustrated in the case of a male youth about 21 years old (Pl's. XXXIII, XLI, XLII). The gaping irregular hole in the left temple is 5.7 by 4.8 cm. in dimensions. The frontal and left parietal both suffered loss, especially the former; the lower margin of the aperture rests on the left wing of the sphenoid. The irregular contour and the undercutting along more than two-thirds of the margin point to a fracture, although there are no traces of fissures in the surrounding bone. Only the short stretch of margin bordering on the parietal has the appearance of having been shaped by the surgeon's instrument, but all the positive traces have been obliterated by healing. Two assumptions are permissible; one is that the fracture was relieved by trephining; the other that the bone had sloughed out. The latter assumption would of course be strengthened could it be proved beyond question that the ancient Peruvians made use of antiseptics. The head had been deformed in the Aymara fashion. The anomalous character of the dentition is revealed in left lower figure Pl. XLI. In front of each first premolar is a small alveolus proving that the milk canines were still in situ at decease. Their persistence caused the mal-placement of both permanent canines; the left twisted on its axis is seen directly in front of the lateral incisor; the right did not erupt at all, its impacted position being shown in the radiograph (see Pl. XLII) for which I am indebted to Dr. Frank G. Baldwin. A part of the mummy to which this belonged was recovered (Pl. VI).

Another remarkable example of nature's healing power is presented in Pl. XXIII. The age of the individual was about 40 and the sex presumably female. The Aymara deformation is barely perceptible. A stellar fracture central over the left parietal eminence played havoc with that bone. Three radiating fissures are still visible; the largest of these is open all the way to the squamosal suture. There is no present indication that the fracture was followed by trepanation, yet the

broken bone may have been thus removed, or a sloughing process might have disposed of the broken parts. The altered character of the bony tissue over a considerable area above and back of the aperture might be attributed to infection of the wound.

In the right upper figure of plate XXIII, representing a male some 60 years old, the aperture in the left parietal has the appearance of being due to trepanation; this would be the easiest way of accounting for the decided bevel in the external table surrounding the aperture. On the other hand the oblong pit central over the left zygomatic suture is in all probability the result of a lesion; it is outside the beaten track of trephining operations.

The skull of a male about 60 years old (Pl. XXIII, left lower fig.), presents another one of those puzzling cases which would seem to be fittingly described as the result of a saber stroke, the scar being more dished in one direction than in the other. The plausibility of such an explanation would be much enhanced had we proof that this and the other skulls similarly disfigured belonged to the period of early Spanish occupation.

On the other hand the small aperture with sloping margins in the right half of the frontal near the coronal suture in the skull of a male about 55 years old is almost beyond peradventure due to trepanation Pl. XXIII (right lower). Judging from the condition of the surrounding bone a mild case of osteoperiostitis followed the operation. We have in this instance, a case that might well have been placed in the previous group; for in my own opinion there can no longer be any reasonable doubt of its being anything else than trepanation. The external table was removed over an area 3.6 by 2.7 cm., exposing the thin walls of the inner table as would happen in an operation by means of scraping. There is no trace of fracture or antecedent bone disease. The skull is that of a female with slight Aymara deformation.

A curious phenomenon is presented in the skull of a female about 28 years old with sharply defined Aymara deformation (Pl. XXXIII, left lower). The latter caused a bulging outward of the upper part of the occipital. The protruding bone has been cut away just below the lambda and to the left of a median plane in such a manner as to leave a perfectly flat field 3.5 by 3.0 cm. in dimension. The surface even has the appearance of having been polished. The bone had healed but not so fully as in some other cases. In my judgment this specimen belongs in the category of trepanations.

The skull of a male some 70 years old with Aymara deformation is reproduced in Pl. XXXIII, right lower figure. On the left side of the

frontal below the temporal crest the external table has been removed from a field 3 by 2.5 cm. in dimensions; near the center of this field there is an oblong hole almost bridged by two tongues of bone. In the left parietal near the vertex loss of the external table occurs over a nearly circular area 3.2 by 3 cm.; near the center of this area is a pit that reaches to but does not penetrate the internal table. Trepanation by scraping or by cauterization would produce just such results as are seen here and on the frontal, and it is difficult to conceive of anything else that would account for them. This skull also, therefore, might well have been included in the preceding group. A part of the skeleton was recovered with it and everywhere the bone is uniformly and seriously affected by osteoporosis; it must have given way under the slightest strain, in fact there are numerous indications of breaks that had healed after a fashion. Might not the unstable condition of the osseous frame-work have furnished the motive for the two operations?

The last skull of the series from Paucarcancha belonging to this group is that of a female about 24 years of age, also with Aymara deformation (see Pl. XXXVII). An oval cicatrice 3.5 by 2.5 cm. overlaps the sagittal suture just above the obelion. The diploe was laid bare but the inner table escaped. This case is not so obvious as the preceding and yet I should be inclined to call it trepanation.

One of the best examples of what seems to be a combination of scraping and cauterization is furnished by the skull of an adult female about 55 years old, from Patallacta (Pl. XXXIV, left upper fig.). The scene of operation is the vertex, the two parietals being affected to an equal extent. The removal of the external table occurred over a field 5.6 by 4.3 cm. in extent. Within this field and wholly in the left parietal a large deep pit was sunk to the level of the internal table. The bone was not diseased; and the motive for the operation is not evident.

Torontoy affords a similar case in the fragmentary skull of an adult male (Pl. XXXIV, right upper fig.), the right parietal near the angle of the lambda being the region affected. A bit of the lower portion of the cicatrice has been carried away by a post-mortem break. Here again there is a deep pit not in the centre of the field but near one margin. The bone was not diseased.

A similar cicatrice including a pit occurs between the right parietal eminence and the sagittal suture of a perfect cranium from cave number 11 at Huata. The area affected measures 4.5 by 3.7 cm., and the pit is near its margin. The bone had healed.

By way of contrast, there is a case involving the loss of the external

table and even producing an aperture. It is that of an adult male about 26 years old. The aperture in the line of the right coronal suture is near the center of a nearly circular field, from which the external table has been eaten away by something resembling syphilitic necrosis. The disease has appeared also above the obelion spreading to both parietals and causing the loss of the external table. These two spots bear a wholly different aspect from the cases of trepanation previously cited (Pl. XLI).

In the left lower figure Pl. XXXIV, we have what seems to be the unusual association of a fracture and trepanation by means of scraping. The cranium is of a female some 50 years old with Aymara deformation. The area affected is nearly central over the left parietal eminence and covers 3.6 by 2.6 cm. In its lower half is a nearly circular aperture 13 mm. in diameter with jagged margin. The remains of what was almost certainly a crack extends from the anterior margin of the hole forward to the coronal suture. Just back of this larger field and in contact with it is a smaller one from which the external table alone has been removed. The healing of the bone in both cases is well advanced. The left zygomatic arch had been crushed in probably coincident with the injury to the left parietal. In addition on the right of the frontal midway of the metopic suture there is a superficial oval cicatrice some 20 by 16 mm. in dimensions. Surely the hazards of living were meted out to the female as well as the male portion of the race that once inhabited the highlands of Peru.

Just such a hole as might be made by one of the points of a stellate stone war club of the kind that was in common use among the ancient Peruvians, is situated above the left brow ridge of the skull shown in the right lower figure of Pl. XXXIV. The aperture has a diameter of 2 cm. with rugose undercut margins, about which are signs of inflamation but not of distinct healing. From it runs a crack half way to the right temporal crest. There is nothing visible remaining to suggest any attempt to relieve the fracture by trepanation. Nature probably got rid of the broken bone by means of a sloughing-out process. This male of some 48 years had passed through previous cephalic vicisitudes, as witness the large rugose oval cicatrice 5 by 4 cm. in dimensions between the left parietal eminence and the sagittal suture. It has the appearance of being due to a wound followed by osteitis. There is also to be noted a fracture of the left nasal bone.

A youth of 19 or 20 years, likewise from Patallacta, suffered three fractures of the skull almost certainly from a similar stone war club

(Pl. XXXV). One is situated between the lambda and the obelion and almost wholly to the left of the sagittal suture. The other two, probably inflicted at a single stroke, are in contact with the other in the occipital below and to the left of the lambda. The victim succumbed before any effort was made to relieve these three depressed fractures. In only one of the three are the broken parts of the bone missing and these were evidently lost after death. From this opening there runs a fissure across the mastoid angle of the left parietal and for a short distance into the temporal just above the supra-mastoid crest. In the collection are other examples of the effectiveness of the stone war club, but none quite so convincing and obvious as this one.

In the first two categories of skulls combined there are twenty-nine which are certainly trephined. In the third group there are twenty-nine skulls, eighteen of which are judged to have been trephined. The forty-seven trephined skulls comprise 29 males, 16 females and 2 youths. There are one-third more trephined crania among the males than among the females, the ratio corresponding roughly to 22 per cent of the total number of males (130) and to 15 per cent of the females (108).

In thirteen of the skulls (of both sexes) trepanation followed fracture; in one the operation was to remove diseased bone; in thirty-one there are no visible signs of antecedent disease or wound; and in two post-mortem decay made it impossible to decide whether there had been antecedent traumatism or disease of the bone.

In eight cases, most of them involving fractures, death followed immediately; in eleven there was partial healing; in twenty-six complete healing; and in two the degree of healing could not be determined. One may assume therefore that as practised among the ancient Peruvians, trepanation was by no means a dangerous operation.

Twenty-one of the trephined crania show Aymara deformation, twenty-six are not deformed. Here the ratio is approximately the same as it is for the collection as a whole; Aymara deformation therefore was in no sense a contributory cause of trepanation. In other words, it did not tend to cause troubles the cure for which would be sought in trepanation.

Eliminating skulls represented by very small fragments and those of very young children, out of the 273 remaining, 47 or 17 per cent have undergone at least one trephining operation. But some of the skulls were operated on more than once (in one case five times), so that the percentage of operations to the total number of skulls would be even greater. The ratio therefore of trephined skulls to non-trephined skulls

in the collection under consideration is greater than that in any other collection hitherto described.

This is all the more remarkable when it is recalled that out of a collection of some 135 skulls representing adults of both sexes and youths and children from Machu Picchu, only eight miles in a straight line northwest of Torontoy, not a single case of trepanation has been reported.* Curiously enough at Machu Picchu females predominated (202 f. to 22 m.) even more than do the males in the collections here studied. Why? One hypothesis is that the female skeletons found in such preponderance at Machu Picchu "are largely the remains of Virgins of the Sun and priestesses engaged in the service of the temple." Another is that the normal proportion of the sexes was disturbed by the withdrawal of the males for war purposes. It is now apparent that the two sets of phenomena are complementary, each explanatory of the other. Females had evidently been with drawn from Paucarcancha, Patallacta, Torontoy, and Huata and assembled at Machu Picchu. Neither would explain the total absence of trepanation from Machu Picchu. The two combined however would go far toward doing so. Injuries to the head requiring this operation would be more frequent in and near the war zone; thaumaturgic motives however need hardly be more potent than elsewhere. One would still expect to find at least some cases in an assemblage of 135 crania unless perchance at Machu Picchu trepanation was taboo. Some such establishment as the "Acclahuasicuna" with its Virgins of the Sun and priestesses would be a logical explanation for the taboo. Furthermore in a group of picked individuals the number of potential cases that might under the circumstances lead to an operation would be automatically reduced.

By a study of the position of fractures and trephining operations one can make out a good case for the assumption that their high percentage marks a period of warfare among the Incas. So far as we know among barbaric as well as civilized races a majority of both sexes are right handed. In combat therefore the left side of the head would be exposed to greater danger than the right. If the fractures and trepanations are found to be prevailingly on the left side, then their position is not fortuitous but controlled rather by the exigencies of combat. It was thought best to set aside all cases of partial trephining—those that affected the external table only. We shall first consider the cases of fracture not followed by an operation but which were fatal.

*G. F. Eaton. The collection of osteological material from Machu Picchu. *Mem. Conn. Acad. Arts & Sci.*, 1916, V.

Of the twenty in this class, eleven had suffered injury to the left side of the head and only three to the right side. The wounds of the remaining six were either on the front or back of the head and these might have been fortuitous, though they might equally have been due to warfare. But no theory of chance could explain away the great preponderance of injuries to the left side in the first fourteen cases cited. In one of these there was a fracture of the left scapula also.

The second lot consists of fractures that were not fatal and which apparently were not followed by an operation. Of the seven skulls in this group five had been fractured on the left side and only one on the right. In the seventh, the wound had been on the front.

In eight other cases fractures were followed by operations and death. Of these six were on the left side and only one on the right. In the two cases where the victim survived both the fracture and the operation, the wound had been inflicted on the left side and on the left rear.

The largest group of all consists of skulls in which the operation might have removed all traces of an antecedent fracture. In twelve cases out of a total of twenty-one, the operation was on the left side, in eight on the right side, and in one on the back of the skull. Seventeen out of the twenty-one had survived.

From a study of these various groups it is obvious that with the possible exception of the last in part, chance had nothing to do with the location of the fracture or operation. On the other hand a different situation exists in the list of partial operations, i. e., where the external table only was removed or where the trouble was superficial. Here all parts of the skull were about equally affected. They represent either accidental wounds or thaumaturgic operations.

In brief, the burial caves in question represent probably a period of strife in the history of the highlands of Peru, a period which tended to develop the use of surgery. In rare instances the knife was employed to remove diseased bone. In some 28 per cent of the cases the operation was to relieve depressed fractures. As a rule however the operation either obliterated all trace of its cause or else the cause was not of such a nature as to affect the osseous system.

That the stone war club with stellate points was the weapon that caused many of the depressed fractures, there can be little doubt. Some of these fractures were successfully relieved by trephining. Other cases were hopeless. Perhaps the best example of this sort is seen in the youth from Patallacta who suffered three fractures of the skull from such a war club (Pl. XXXV). In this class belong several skulls from

Paucarcancha. The otherwise complete cranium of a male about 60 years old (Cat. No. 37) is crushed in at about the center of the frontal bone. The approximately round hole is the size that would be made by a point of the average war club. The margins are undercut and the break was made while the bone was green. There is no sign of even the beginning of healing. There is a cicatrice over the right orbit and the nasal bones are bent abruptly toward the left side.

On the back of the skull of an adult male (Cat. No. 103) there are three fractures that look suspiciously like wounds due to a star-shaped war club. The one in the region of the obelion and to the right of the sagittal suture broke completely through. The one in the occipital near the left branch of the lambdoid suture broke through but the bone fragments were not wholly dislodged. The third in the left parietal, is due to a still lighter blow.

Another case worthy to be cited, is that of an adult male some 23 years old (Cat. No. 182). In the left parietal just back of the coronal suture there is a round hole. A second round hole of about the same size is in the occipital bone a little below and to the right of the lambda. From this round hole there is one radiating fissure. The holes were broken in while the bone was green. In view of their size, shape and locality, it is reasonable to suppose that they had been produced by the stellate stone war club.

TRAUMATISM

It was noted under the subject of surgery that a majority of the trepanations were to relieve depressed fractures, and in that connection a number of traumatic cases were cited which were not followed by an operation. Nasal bones and zygomatic arches that have been broken and healed are frequent, as also are wounds above or below the eyes. This is evidence that Peruvian highlanders were both brave and pugnacious. An illustration of this is shown in an adult male cranium some 75 years old from Paucarcancha (Pl. XXXV). A great scar over the right orbit reaching from the fronto-malar suture to and across the nasal bridge, testifies to the victim's ability to stand punishment. About midway of the scar the frontal sinus is penetrated. Both orbits are altered in shape as a result of the wound, which had presumably been received in the period of youth. The cranium is artificially deformed.

In another adult male from Paucarcancha (cat. no. 112), the left side of the face had been smashed, the blow having fallen on the maxilla and nose. In the process of healing fissures were left in the bones and

the shape of the orbit was changed. This individual lived to the age of about 70 years. The loss of all the teeth had been followed by complete resorption of the alveolar arch. The cranium is artificially deformed.

The infra-orbital region is the seat of an injury to another cranium from Paucarcancha, that of an adult female about 40 years old. The bony tissue is gone from the left maxilla directly beneath the infra-orbital foramen, leaving a cavity as large as the end of one's middle finger. Curiously enough a premature obliteration of the left branch of the coronal suture had taken place, while all the other sutures had not begun to show signs of disappearing. The teeth were all lost during life and the alveoli had become resorbed.

In a female cranium from Paucarcancha (cat. no. 86), the nose had been broken and both zygomatic arches caved in during life.

A remarkable case which probably has more to do with teratology than with traumatism, is that of a vertebral column from Paucarcancha (cat. no. 300). There is not enough of the skeleton present to pronounce upon the sex, but the size of the scapula and its condition of growth point to an adult male. The vertebrae from the sixth or seventh cervical to and including the twelfth thoracic are still united. The first three of the series are fused. A sharp lateral bend occurs at about the level of the fourth thoracic vertebra. These two sections are the seat of a very early injury dating from near the period of birth. At the level of the third right rib there is a wedge-shaped undeveloped supernumerary vertebra; and at the level of the fifth rib on the same side there is a second wedgeshaped undeveloped supernumerary vertebra. These two wedges account mechanically for the lateral deflection in this region. There are thirteen rib scars on the right side, the extra rib being borne by one of the vertebral wedges. On the left side there are twelve rib scars, the normal number. The proximal ends of the first four ribs on this side are fused into a single mass of bone (Pl. XLIV).

The left humerus of a male from Torontoy (cat. no. 821) had suffered a compound fracture a short distance above the elbow joint. The wound evidently became infected, for the fragment of bone sloughed out. The healing process was finally completed. The two portions of this humerus came to New Haven in separate boxes. A diligent search to bring them together again was finally rewarded (Pl. XLIV).

A case of pseudo-arthrosis somewhat similar to the foregoing, was discovered at Huata, a broken right tibia (Pl. XLIV) that had become infected and failed to join (cat. no. 900).

A remarkable example of fracture of the joint and of osteomyelitis is furnished by a left arm from Huata (cat. no. 901). The humerus and ulna are completely fused; the radius remained free and is now lacking. A short distance above the elbow joint a movable fragment of bone is imprisoned in an oblong cavity producing what is called an involucrum. The enlargement of the humerus midway of the shaft is due to the effort of nature to rid itself of this involucrum (Pl. XXXVIII).

Another rigid left arm was found at Paucarcancha (cat. no. 270). The elbow joint only is affected. At this point, humerus, radius, and ulna are all fused at an angle of about 135° (Pl. XXXVIII).

The collection includes two rigid ankle joints: the left joint of an adult male from Patallacta, and the right joint of an adult female from Paucarcancha. In each case the trouble started from a wound. There is a scar on the male tibia in front and just below midway of the shaft. The distal end of the fibula belonging with this tibia is enlarged and misshapen, indicating that it too had been injured by the fracture at the ankle, which was the one that caused the fusion of the ankle bones with the tibia (Pl. XLVIII). A fibula from Paucarcancha exhibits a similar condition (Pl. XLVIII).

The wound that caused the stiff joint of the female was inflicted on the median malleolus, at which point there is a deep indentation. In this case the fusion does not include the calcaneum (Pl. XLVIII).

The distal end of a tibia from Torontoy is enlarged to almost twice its normal size because of an injury and the articular surfaces between the tibia and the astragalus were seriously affected by inflamation. The joint must have been stiff if not rigid.

A very serious injury to the knee joint is represented in a left tibia from Paucarcancha (cat. no. 269, Pl. XLVIII). The trouble was caused either by a comminuted fracture of the tibia or an arthritic lesion. The median condyle is greatly enlarged and below it there is a fistula from which runs a canal for some distance downward. The whole upper half of the shaft is enlarged and rugose. The articular surfaces at the knee are rough and uneven.

The left tibia of an adult male from Paucarcancha (cat. no. 282a) suffered an injury about one-third way up from the malleolus. The result was the enlargement of the shaft and the development of a large fistula (Pl. XLVIII).

From Paucarcancha came a fine example of an oblique fracture of both tibia and fibula on the right side (cat. no. 268). Both bones are

enlarged and bent at the seat of injury, which is likewise marked by a perforation of the fibula (Pl. XLVIII).

There are several interesting examples of ankylosis or synostosis that may, or may not have had a traumatic origin. In the skull of a youth some 20 years of age from Paucarcancha, the atlas is firmly fused with the right occipital condyle and with the margin of the foramen magnum on the right side and back of the hypoglossal canal. The median portion of the posterior arch of the atlas had never developed. The cranium had been trephined (Pls. XXXII, XXXVIII).

In an adult female about 40 years old, also from Paucarcancha, the atlas is fused to both occipital condyles and to the margin of the foramen magnum on the left side, back of the hypoglossal canal. The posterior arch of the atlas, which is broken and lost, was apparently very slender (cat. no. 2).

There are examples also of the fusion of other adjacent bones, the cause of which was probably not traumatic. One such is the union of the first and second ribs for their entire length, except at the ventral or sternal ends (cat. no. 712).

PATHOLOGY[1]

Injuries and disease are almost as old as life itself. Caries, for example, occurs already among fossil vertebrates; according to Renault it is found in Permian fishes that lived 20,000,000 years ago. Pyorrhea alveolaris, fracture, callus, and parasitism also date from the Paleozoic period. During the Mesozoic one finds lesions on the bones of dinosaurs, turtles, crocodiles, and other reptiles similar to those produced in modern times by periostitis, necrosis, arthritis, osteoma. Fossil animal remains from Tertiary deposits afford evidence of the existence of numerous diseases. Fossil races of man were by no means free from many of the ills which afflicted the races of more recent times.

In the chapter on SURGERY it was pointed out that in but a single case is it obvious that the operation was to remove diseased bone. This is surprising in view of the relative frequency of trepanation among the ancient Peruvians. The lone case is that of an adult listed as a male about thirty years old from Torontoy (right upper fig., Pl. XXVII). The disease had honeycombed the cranium on the right side affecting about equally the frontal and the parietal. Death followed evidently soon after the operation.

[1]Pathology of the alveolar processes and teeth is reserved for the chapter on Dentition.

A picturesque and at the same time gruesome example is to be seen in an adult male some sixty years old from Paucarcancha. Osteosarcoma, a variety of bone cancer, had produced an enormous bony excrescence reaching from the left frontal eminence to the left parietal, and encroaching for some distance on the right parietal (Pl. XXXIX). The height of this osteophytic excrescence is about 4.5 cm. Underneath all but its outer margin, the walls of the cranium are entirely gone. The bone outside the boundaries of the cancerous growth is changed for a considerable distance, so that the total area affected forms an oval measuring about 14 by 11 cm. The growth of this excrescence must have continued through a period of years.

The cranium of a child about six years of age from Paucarcancha exhibits a diseased condition all the way across the left parietal and overlapping on the left side of the frontal for a distance of 2 cm., (cat. no. 51). The seat of trouble is chiefly in the external table, the greater part of which has disappeared entirely. There is a more or less distinct line of demarcation surrounding the affected field. In only one small oval area does the honey-combing process penetrate the internal table. The disease was probably syphilis (Pl. XXXVIII).

A condition having the appearance of syphilitic necrosis is seen in the cranium of an adult male about twenty-six years old from Patallacta (cat. no. 635). The disease had eaten away the external table over a circular area 4.8 cm., in diameter, two-thirds of which is in the right parietal and one-third in the frontal; and had even penetrated the diploe and internal table near the center of the affected area, leaving a hole some 8 mm. in diameter. Two contiguous fields in the region of the obelion are also affected to the extent of complete removal of the external table. Just back of the left stephanion is an oval cicatrice 2.3 by 1.6 cm., in dimensions, apparently due also to disease (Pl. XLI). In the anterior temporal regions there is a suggestion of a former hydrocephalous condition.

Disease has eaten away the bone in the cranium of a child some eight years old from Patallacta (cat. no. 938). The area affected is circular with an average diameter of 4.2 cm., and reaches from the lambdoid suture more than half way to the left parietal eminence; The disease was probably of a syphilitic nature (Pl. XXXVIII).

There is one pronounced case of osteomalacia in an adult male some seventy years old from Paucarcancha (cat. no. 174). Of the total skeleton there are present the cranium and lower jaw, eighteen vertebrae, clavicles, one scapula, right humerus, nineteen ribs, and practically the

whole of the manubrium and sternum. All are equally affected by the disease and are excessively light, due to absorption of bone substance and enlargement of the meduallary canals. The cranium had been subjected to Aymara deformation, and had been twice trephined, one operation being complete and the other partial (Pl. XXXIII). It is difficult to understand how such a frail framework could have supported a body under the conditions then prevailing in the Peruvian highlands.

The rather large cranium of a female about twenty-four years old from Paucarcancha (cat. no. 190) has undergone a curious pathological deformation resulting in a broad, deep transverse depression just back of the bregma (Pl. XXXVII). The subject exhibits a slight partial trephining operation in the region of the lambda. Whether the operation was to relieve the trouble that caused the deformation has not been ascertained. This deformation is known as cimbocephaly.

Among the other unusual features of this cranium are: the failure of the lachrymal bones to develop, metopic suture, infantile piriform nasal aperture, large squarish dental arch, displacement of the right upper permanent canine due to persistence of the milk canine, large spinous processes, flattened external auditory openings, small third condyle, prominent paracondyloid processes, and a spheno-maxillary articulation on the right side. The sacrum belonging with this cranium either has an imperfect first segment or else it has only four segments and the last lumbar vertebra is fused on one side with the first sacral segment.

In the series of female crania from Paucarcancha there are two good examples of osteoma. The first bears the catalogue number 9, and is from a woman about thirty-five years old. The bony growth is situated on the occipital just back of the left mastoid process; in shape and size it resembles a hickory nut. This cranium has an Inca bone which is divided by a vertical suture line into two unequal halves. The second skull is that of a woman about fifty years old. The bony prominence is on the right parietal near the tuberosity, and is oval in shape with a length of 2 cm., and breadth of 1.3 cm. The cranium had been subjected to Aymara deformation. The presence of a metopic suture is also to be noted.

Arthritis seems to have been a rather common disease among natives of the Peruvian highlands. It affected the joints in various parts of the body. There are some interesting cases of its occurrence in the hip joint. It affected both hip joints of a male from Paucarcancha (cat. no. 274). The variety is arthritis deformans, producing what Hrdlička

called mushroom head[1] to the femora. The hip sockets are correspondingly affected, being shallow but much enlarged in respect to their diameters (Pl. XLVII). Only a portion of the skeleton is present including in addition to pelvis and femora, four lumbar vertebrae, the tibiae and fibulae, and a few bones of the feet. The lumbar vertebrae are also arthritic but in a minor degree.

The mushroom condition of femoral head is present on both sides in a youth from Patallacta (cat. no. 991), on the left femur of an adult male from Paucarcancha, and on the right femur of an adult female also from Paucarcancha.

The chief seats of arthritis are the vertebral column, the limb joints, and the temporo-mandibular joints. The trouble was by no means rare. One of the best examples from the vertebral column is reproduced in Plate XLVII. The two vertebrae are from Patallacta and are evidently those of a male. In addition to the radiating fringes of bone decorating the margins of the two, there is a clamp of bone fused solidly with the body of the lower of the two vertebrae and articulating with that of the upper bone. The condition illustrated by these specimens is known as spondylitis deformans.

Among the long bones the tibia seems to have been affected by disease more often than any other. There are several which have every appearance of being syphilitic. Whether syphilis existed in the New World prior to the discovery by Columbus cannot be settled by the collection under study here. Some of the burials in the highlands of Peru were evidently post-Columbian. (cat. nos. 272, 283a, 288a). Three seemingly syphilitic tibae from Paucarcancha are reproduced in Plate XLIX.

A pair of male tibae belonging to one indivdual and found at Patallacta are affected to an even greater degree (cat. no. 1006). The bones had become much enlarged in size and curved in a forward direction. The surfaces are uneven. The left tibia has been more seriously affected than the right and near its distal end there is a large cavity formed in the bone (Pl. XLIX). In a left humerus, also from Patallacta, we find the same trouble, only in its earlier stages.

A right tibia from Torontoy (cat. no. 788) has undergone changes practically as great as in the case of the two tibae from Paucarcancha. Other examples could be cited, but the ones here mentioned are the most marked.

[1]Anthropological Work in Peru in 1913, with Notes on the Pathology of the Ancient Peruvians. *Smithson Misc., Colls.*, No. 2246, Wash., 1914.

There are several examples of periostitis and osteoperiostitis. Two cases of periostitis may be cited from Paucarcancha, two female femora (cat. nos. 540, 546).

CRANIA

The great divergence in and the frequent occurrence of small cranial capacity have already been noted; also the presence of more than one cranial type, and the frequency with which artificial deformation of the cranium occurs.

The smallest normal adult female cranium has a capacity of 1,020 cc.; the capacity of the largest normal adult male skull is 1,670 cc.

Brachycephaly, mesocephaly, and dolichocephaly are all represented and in varying degree. Of the 149 crania measured, 89 are mesocephalic, 50 dolichocephalic, and only 10 brachycephalic. The lowest index (69.7) is found in a male cranium from Torontoy; the highest (82.9) occurs in a male cranium from Paucarcancha.

The height from basion to bregma does not vary greatly, nevertheless there is a somewhat wider gap between the extremes of the height-length index than between those of the cephalic index. The greatest height-length index is 84.8, in a male from Paucarcancha; the smallest index is 70.0, in a female from Torontoy. The excess of height over breadth is also to be noted in the height-breadth indices, the majority of which are above 100.

Sex characters on the cranium alone are often so evenly balanced that it is difficult or even impossible to pronounce definitely upon the matter of sex. Capacity is only one of the criteria. One cranium from Paucarcancha, classed as male, has a capacity of only 1,110 cc. The capacity of another cranium from Paucarcancha, classed as male, drops as low as 1,115 cc. The smallest male leg and arm bones are likewise from Paucarcancha; as is also the smallest female cranium, with a capacity of 1,020 cc.

A minimum facial angle of 63° is recorded from two crania, both males about fifty-five years old (cat. nos. 129 and 877). The largest angle, 79°, belongs to a female also about fifty-five years old (cat. no. 130).

The alveolar angle is more variable than the facial angle. The tables show that the minimum angle, 37°, is reached in a female cranium (cat. no. 2), and that the maximum angle, 74.5°, is found among the male crania (cat. no. 189).

The facial angle is the angle between the basion-prosthion line and the

prosthion-nasion line. The alveolar angle is the angle between the basion-prosthion line and the prosthion sub-nasal point line.

The extremes of variation in the upper facial index are found in a male about sixty years old (cat. no. 127) with an index of 43.7; and in a male about forty-eight years old (cat. no. 638) with an index of 59.5.

A minimum orbital index of 83.8 is met with in three crania: no. 1, a female, and nos. 59 and 956, both males. The orbital index reaches its maximum for the series (108.8) in a male some twenty-six years old (cat. no. 160).

The maximum and minimum figures for the nasal index go to females. A minimum of 30.6 is touched but once, in cranium no. 73. The largest index, 60, occurs in two crania, nos. 61 and 888.

The index of palate ranges from 71.7 in a female (no. 83) to 107.5 in a male (no. 921).

Sutures.—The sutures exhibit a wide range of variation from very simple to highly complex. Some of the patterns are remarkably beautiful and symmetrical. The lambdoid and squamosal are generally the last to disappear. Only two of the crania exhibit a brusque or premature obliteration of the sutures. In a female cranium from Paucarcancha (cat. no. 18), the left branch of the coronal suture is affected; all others are wide open. In a male cranium from Torontoy (cat. no. 760), there is a complete and premature obliteration of the sagittal suture. The female was not over forty, and the male not over thirty-eight years old at decease. In neither skull is there anything to indicate the cause of the brusque disappearance of the sutures in question.

The metopic suture closes normally between the ages of one and two years. Its persistence beyond the age of two years is here noted in twenty-six crania or approximately 9 per cent. of the total number. It often persists until old age, being among the last of the sutures to disappear.

In the child's skull the anterior or bregma fontanelle normally closes also between the first and second year. Its failure to close at the allotted time is much less frequent than that of the metopic suture. There is just one case in the series where the closing process of the fontanelle has been distinctly retarded: that of a child at least three years old from Sillque (cat. no. 917). The metopic suture is also open (Pl. XL).

A basilar view of the same cranium reveals another peculiarity: a so-called node of Kerckering, or failure of the occipital bone to develop in the region of the opisthion (Pl. XL). This condition gives to the antero-

posterior diameter of the foramen magnum an exaggerated length. The milk incisors and canines have dropped out since decease; the four milk molars are still in situ, and the first permanent molars as well as incisors are beginning to erupt. Another retarded feature is the wide-open squamo-mastoid sutures, which should normally close by the end of the second year. The occipital still exhibits three distinct parts, an unpaired basilar, a paired condylar, and an unpaired tabular portion, which is to be expected in a cranium of this age.

The case just cited of a persistence of the squamo-mastoid suture is only one out of thirty. This suture thus remains open after the second year in about 10 per cent. of all the crania in the collection,—an unusually high percentage. Crania that have the open squamo-mastoid suture are apt to have other infantile characters as is well illustrated in the specimen (cat. no. 1) shown in Pl. XVI. The squamo-mastoid suture is likewise seen to good advantage in one of the skulls in Pl. XL and in another shown in Pl. XLI.

Region of the Pterion.—The place of meeting of either the sphenoid and parietal or the frontal and temporal, or all four, has been the subject of intensive study. Usually in man the suture lines in this region form a capital letter H, with the cross mark representing the line of junction between the sphenoid and the parietal bones. Rarely the suture lines form a capital letter K, in which case all four bones meet at a point. There is only one such in the collection (cat. no. 140). Not infrequently there is a temporo-frontal articulation producing what is sometimes called a reversed pterion. This is the usual condition among anthropoids and lower mammals. The temporo-frontal articulation occurs in nine skulls of the Peruvian collection, on both sides in eight crania and on one side in one. A good illustration of the reversed pterion is seen in one of the skulls in Pl. XXXVI, where it occurs on both sides (cat. no. 636).

Wormian Bones.—These bones, varying from three or four centimeters in diameter to the size of a pin head, are found along the suture lines, especially the lambdoid, sagittal, and parieto-mastoid sutures and in the region of the pterion. Very frequently there is a good sized wormian bone at the anterior end of the parieto-mastoid suture. Its presence is noted less frequently at the asterion. There are ten crania with pterionic wormian bones. In several crania there is a stack of large wormian bones reaching from the lambda to the obelion.

Inca and Epactal Bones.—Special bones that occur in the lambdoid angle are known as epactal bones. Eleven of the Peruvain crania have

epactal bones. In nine the bone is single, in two it is double (see Pl. XVI). The so-called *Os Incae* is much larger than the epactal. The Inca bone fills the entire lambdoid angle down to the level of the two asterions. There are six examples of such Inca bone in the collection.

Norma basilaris.—There are several features about the base of the cranium that require special study. Between the condyles and the mastoids there is occasionally a fairly well-developed process on one or both sides, the paramastoid, paracondyloid or paroccipital process. A splendid example of such paramastoid process on each side occurs in the cranium of a female about forty years old from Torontoy (cat. no. 769). They even articulate on their anterior surfaces with the lateral processes of the atlas, the articular facets on both bones being quite distinct (Pl. XL). An equally large paramastoid process is found on a female some thirty years old from Paucarcancha (cat. no. 95), but only on one side. This is one of the few crania with a third condyle. The paramastoid processes are prominent in at least five other crania of the collection.

The condyloid canals are totally lacking in 49 crania; in three they are double; and in eight, instead of passing underneath the condyles they pass under bridges that connect the condyles with the paramastoid processes. The hypoglossal canals are much more constant. In fifteen cases the hypoglossal canals are double on one or both sides of the foramen magnum.

In birds and scaly reptiles there is an unpaired median condyle. This median or third condyle occurs sporadically in man. There are three fairly well-developed examples in the collection (see Pls. XXXVII and XL).

In the collection there is a marked tendency toward an incomplete formation (dehiscence) of the bony floor to the external auditory meatus. The floor is often not only thin, but actually perforated. This perforated condition, which is known to be frequent in Peru, occurs on one or both sides in ninety-eight of our crania, or over 30 per cent. The condition is usually associated with large middle lacerated foramina.

An ossification in the ligamentum pterygo-spinosum results in the production of spheno-pterygoid processes or a foramen. When the foramen is complete the processes from the pterygoid lamina and the spina angularis meet in a suture line. Turner found the spheno-pterygoid foramen with complete osseous boundaries in three skulls of the Challenger series. The author found it in two out of a series of twenty-four crania from the Gazelle Peninsula, New Britain. In the

Peruvian collection there are nine examples—seven on the right side and two on the left.

Norma Lateralis.—When the malar bone fails posteriorly to reach the lower orbital fissure, there takes place the union of the great wing of the sphenoid with the superior maxillary bone, producing what is called the spheno-maxillary articulation. This articulation is noted on one or both sides in seventeen of the crania.

On the posterior margin of the frontal process of the malar bone there is generally the suggestion of a process. In individual cases it can be very prominent and is referred to as processus marginalis. This process is prominent on forty-four of the Peruvain crania. A good example is shown in Pl. XLI.

The persistence of a horizontal suture dividing the malar bone into an upper and a lower portion, accounts for the phenomenon known as *Os zygomaticum* duplex, also called *Os Japonicum* because of its relative frequency among Japanese crania. In our collection there is not a single example of this kind.

Norma frontalis.—But a single feature will be mentioned—the anterior nasal opening. Three or four types of the piriform aperture have been described. In the first place there is the dominant human form with rather sharp margins in the region of the nasal incisures and a prominent nasal spine. Then comes the infantile form with gently rounded incisural margins and feebly developed nasal spine. In the third type the incisural margins are cut away still more, producing "simian gutters."

In the collection there are 49 crania exhibiting the infantile type of piriform aperture, while 23 have fairly well-developed simian gutters.

Norma posterior.—There is little to add in respect to this aspect of the cranium, except to mention certain foraminal anomalies. One would expect to find two parietal foramina in the region of the obelion, one on each side of the sagittal suture. As a matter of fact one of these is often suppressed. In fifteen of the Peruvian crania both foramina are completely lacking. In one case there are two on the same side of the sagittal suture; while in each of two crania there are four parietal foramina, three on one side and one on the other.

The retro-mastoid foramina vary in number and size. In four crania they are especially large; in one they are completely lacking; and in another the two are both on the same side.

PALATE AND TEETH

The denture has been observed in 422 cases. In some of these, both jaws are represented; in others only one jaw, the upper or the lower. The jaws of children are not included. The shape of the jaw depends upon the conformation of the lateral branches between canines and third molars. If they are rectilinear and parallel, the arch is U-shaped or hypsiloid (a simian form). Curvilinear divergent branches produce a hyperbolic type, the most common human form. On the other hand, curvilinear convergent branches produce an elliptic type. In the collection there are three crania with characteristic elliptic dental arches.

The palate exhibits pronounced individual variations. In a few cases it has a depth of nearly 2 cm.; in others it is very shallow. In three examples, the breadth exceeds the length. The excess of breadth is greatest in a male cranium from Huispang (cat. no. 921) with a palatal index of 107.5. This cranium has a cleft palate, the only example in the collection (see Pl. XIV). The minimum index, 71.7, is found on a female cranium from Paucarcancha.

The external or labial wall of the alveolus is often so thin that the roots of the teeth not only show through but are largely bare and stand out in a series of parallel ridges, which are all the more conspicuous, as is frequently the case, when the roots are large.

A large majority of the jaws have sixteen teeth. If every cranium could be matched with its lower jaw and every lower jaw with its cranium, skulls with thirty-two teeth would no doubt be well in the lead. Relatively few jaws have either fifteen or fourteen teeth. While two third molars are nearly always present in each jaw, it sometimes occurs that one of the two is lacking. Again there may be two in the upper jaw and none in the lower. The third molars are smaller than the first or second molars. There are no supernumerary teeth. In one case there is an apparent fusion of two teeth—an upper right first premolar with canine (see Pl. XVI), so that although both third molars were present at decease, the jaw had only fifteen teeth. The retention of milk teeth is noted in twelve cases and in every case but one has caused the displacement or suppression of teeth of the permanent dentition.

A displacement or malposition of teeth occurs in twenty-four cases and, as just stated, at least twleve of these are due to the retention of milk teeth. In a youth about twenty years old from Paucarcancha (cat. no. 7), the milk canines still persist in the upper jaw causing the suppression of the lateral permanent incisors. Back of the left upper milk canine is

the socket of the left first milk molar, the retention of which has caused the displacement of the permanent canine and first premolar; the canine is set on the labial side and the premolar on the lingual side. The premolar is also twisted about 90° on its axis. The teeth of the lower jaw have suffered no displacement. All four of the third molars are visible.

In catalogue number 9, the upper left first premolar is set longitudinally in the jaw instead of transversely. The same is true of the upper right first premolar in catalogue number 15.

A youth about fourteen or fifteen years old from Paucarcancha (cat. no. 19) had fourteen permanent teeth in the upper jaw at decease, also the right milk canine, the persistence of which caused a serious displacement of the right permanent canine and first premolar. The canine migrated labially and the premolar lingually, becoming twisted in the process. The first premolar on the left side is set longitudinally instead of transversely. The first upper right premolar in catalogue number 59 is twisted nearly 90° on its axis. In catalogue number 63, a male some thirty years old from Paucarcancha, the retention of a milk tooth has caused the displacement of the upper right canine.

A youth of about fifteen years from Paucarcancha lived long enough to experience dental troubles. The third molars were still below the socket level. The dentition of the lower jaw was normal. In the upper jaw the canines usurped the place of the lateral incisors which do not appear at all. There is a diminutive root-shaped dental mass planted labially between the two left premolars. A large bone cist had developed in front of the right upper first molar causing the cave-in of the second premolar.

The denture of a youthful diminutive female about sixteen years old from Paucarcancha (cat. no. 117), exhibits some curious features. The lower jaw is lacking. The conical sockets of the upper third molars indicate that these molars were at least ready to erupt. The four premolars and right canine are fully formed; the canine and the right first premolar are however displaced. A tooth, probably the left canine, was just beginning to break through the palate to the left of the foramen incisivum. The sockets of the molars bear witness that pyorrhea alveolaris had already done serious mischief.

A good example of the mischief that can be done by the persistence of milk teeth has already been seen in a skull that had been subjected to trepanation (Pls. XXXIII, XLI), a male about twenty-one years old. There are no third molars in sight, and no irregularity about the dentition

of the lower jaw. Because of the retention of the upper milk canines, which were still in place at decease, the left permanent canine had been seriously displaced to a position directly external to the lateral incisor and implanted longitudinally instead of transversely. Although well-developed as brought out by a radiograph, the right canine is securely impacted near the anterior nasal opening (Pl. XLII).

The retention of the upper right milk canine is also to be noted in an adult female about twenty-four years old from Paucarcancha (cat. no. 190). It caused the permanent canine to be turned on its axis and set between the lateral incisor and the lip (Pl. XXXVII).

There is a malposition of teeth in an adult female from Patallacta (cat. no. 632) although there is no sign of retained milk teeth. The upper right canine and first premolar are out of line due to crowding.

The female cranium with exaggerated Aymara deformation reproduced in Pl. XXXVI, has a displaced left canine, its labial surface being turned so as to face the first premolar.

A male from Patallacta (cat. no. 643) who had lost all but two of his teeth prior to decease, had an impacted upper right canine which can be seen at the base of two adjacent sockets.

One of the trephined crania (see Pl. XXX) from Patallacta has an impacted tooth resting in a horizontal position at the level of and slightly to the left of the anterior nasal spine. Its crown can be seen in the foramen incisivum. This may be a canine as there does not seem to be a canine socket on the left side. The cranium is that of a female about sixty years old with originally sixteen teeth in the upper jaw, counting the impacted one.

In an adult male cranium from Torontoy the upper left canine and first premolar are displaced. The canine is forced to the labial side and twisted on its axis while the premolar is set longitudinally in its socket and on the lingual side.

A retained upper right milk canine in a female cranium from Patallacta (cat. no. 960) has resulted in an impacted canine, which is imbedded in the maxillary between the infraorbital foramen and the lower end of the nasal aperture.

The upper jaw of a youth between fifteen and eighteen years of age from Patallacta (cat. no. 967) has a displaced canine and a first premolar on the right side due to the retention of the milk canine.

Another youth from the same locality (cat. no. 970) has a displaced upper left lateral incisor situated lingually between the median incisor and the canine. Its diminutive size leads one to conclude that it might

be a retained milk incisor. If this be the case, there is probably an impacted permanent lateral incisor still hidden in the jaw. The second upper left premolar is set longitudinally in the dental arch.

A particularly interesting case of displacement occurs in the cranium of a male from Yanamanchi some twenty-five years old. This is one of the trephined crania (see Pl. XXX). The two upper median milk incisors were still in situ at decease. The right has caused but little trouble, but serious consequences resulted from the continued presence of the left incisor; the left permanent median incisor is impacted and rests in an oblique position with its root projecting by the side of the anterior nasal spine and its crown visible through the foramen incisivum.

In the lower jaw of a youth some sixteen years old from Paucarcancha, the displacement of the left lateral incisor and canine was caused by the retention till decease of the left milk canine (cat. no. 927).

The final example of malplacement to be noted, is in a lower jaw from Patallacta (cat. no. 687). The right canine is planted longitudinally instead of transversely in the jaw.

There are two cases of delayed eruption of teeth without the presence of any visible evidence as to the cause of the delay. The presumption is that in both the delayed eruption of the permanent teeth was caused by the retention for a certain period of the milk teeth. Both lower jaws are from Paucarcancha. The more pronounced case is that of a male about forty years old (cat. no. 193). There are sixteen teeth, all of which are considerably worn except the left canine which was just being cut at the time of decease. Of the thirteen teeth still in situ six are decayed. The genio-hyo-glossal spines in this jaw are unusually large as are also the mylo-hyoid ridges. The other lower jaw is that of a female about twenty years old. Here again it is the lower left canine the growth of which has been retarded (cat. no. 192).

It will be seen from the foregoing that in the Peruvians the displacement of permanent teeth was due in a large measure to the retention of milk teeth, and that the milk tooth most frequently retained is the canine. The cases of retained incisors are much less frequent.

Root anomalies.—A majority of the teeth still in situ stick tightly in their sockets, so that the opportunity to study them is limited. One may however study the sockets of teeth that have dropped out since the time of decease. A partial survey of the material reveals a number of cases of canines with two roots, premolars with two roots, and even lower molars with three roots.

A two-rooted lower canine occurs in two skulls (cat. nos. 92 and 657).

Premolars with two roots are more common. In catalogue numbers 25, 98, 752 and 767 the two upper first premolars both have two roots. One first upper premolar is also two-rooted in catalogue numbers 34, 91 and 106. In catalogue number 746, the second upper premolar has two roots.

The most striking example of root anomaly is seen in an adult female lower jaw from Patallacta (cat. no. 687). There were originally sixteen teeth. The right second molar was lost prior to decease. The left first molar was in place at decease; the other four molars are still present. The left third molar is easily removable and has three distinct roots, one anterior and two posterior (see Pl. XLVII). An alveolar abcess at the roots of the left first molar tends to obscure the evidence, but the socket has the appearance of having once contained a three-rooted molar. On the right side, the first molar is firmly implanted in the jaw; but one can easily see that it has three distinct roots, a large anterior and two posterior roots—the labial one large, and the lingual root small. The right third molar has but two roots and these are partially fused and slope toward a common point. Other features worthy of note in this jaw are the smallness of the sockets for the premolars and the absence of the genio-hyo-glossal spines.

Dental Pathology.—That which impresses the observer is the realtively high mortality among the teeth and the fact that the ancient Peruvians apparantly made little effort to check the loss of teeth. They were experts as primitive races go in cranial surgery, but had not developed or perhaps even begun to develop dental surgery.

In 12 out of 422 jaws the teeth had all disappeared prior to the decease of the individual; in several others all but one or two teeth had been lost during life. In a majority of the subjects at least some teeth had been lost during life. As is to be expected there were a great many post-mortem losses of teeth to be counted by the open empty sockets. Of the teeth which are still in situ a surprisingly large percentage are decayed. The following table gives the necessary data for calculating the percentage of decayed teeth among those still in place:

Skull No.	Teeth present	Teeth decayed	Skull No.	Teeth present	Teeth decayed	Skull No.	Teeth present	Teeth decayed	Skull No.	Teeth present	Teeth decayed
1	5	3	82	11	1	192	11	1	782	14	1
2	7	0	83	25	4	193	13	6	784	6	4
3	12	0	84	2	1	194	9	0	790	22	0
5	9	1	86	9	1	628	6	2	791	7	2
6	11	1	90	3	0	629	7	0	877	10	0
7	20	0	91	5	1	630	8	0	878	10	0
8	5	2	92	5	1	632	8	0	879	14	0
9	4	0	93	27	0	633	8	1	880	8	1
10	4	1	95	11	2	634	7	7	881	11	1
12	14	2	97	4	1	635	16	1	882	19	5
13	6	2	104	6	0	636	9	1	885	7	0
14	4	3	105	6	0	637	12	0	886	16	2
24	2	1	113	6	3	638	27	2	888	7	5
25	1	1	114	4	0	639	17	3	889	2	1
28	11	1	122	13	2	640	11	2	910	7	3
34	2	1	126	11	0	642	5	1	911	9	1
40	8	1	128	3	0	645	12	0	912	3	1
42	2	2	129	16	2	653	4	3	913	3	0
44	9	1	131	8	1	657	12	2	915	20	0
45	3	1	137	2	1	663	10	0	921	28	2
47	19	0	142	9	1	746	7	2	923	12	0
56	16	0	143	6	1	747	24	5	924	3	0
58	4	3	147	8	1	748	9	3	934	4	2
59	9	3	149	11	6	749	6	2	941	4	1
61	5	5	151	3	1	751	12	3	956	9	3
62	4	4	153	16	7	752	5	3	964	11	1
63	11	0	159	14	2	753	16	1	965	4	2
64	3	1	160	17	0	756	11	1	967	6	1
65	8	0	161	24	2	757	32	0	968	8	4
66	6	2	164	4	1	758	21	1			
70	4	1	174	8	4	760	14	2	Teeth present		1,259
77	9	0	182	6	0	761	19	1	Decayed		194
79	6	1	189	5	1	767	4	0	Percentage of decayed		15.4
81	7	2	190	11	1	769	14	0			

In addition to the foregoing, there are several dozen unmatched lower jaws and the percentage of decayed teeth to teeth present would average about the same as in the table.

The chief cause of loss of teeth outside of caries seems to have been pyorrhea alveolaris, which has affected more than 13 percent. of all the jaws. Alveolar abcesses are present in twenty-two cases (Pl. XLII); bone cists in ten (see Pl. XXI); caries of the jaw in six; and maxillary

necrosis in one. The cases where there is a marked formation of tartar number thirteen.

STERNUM

The sterna are seventeen in number, ten males and seven females. The sternum is one of the most variable bones of the entire skeleton. The chief sexual difference is in the ratio of the manubrial length to that of the mesosternum. In the male the manubrium is relatively short, while in the female it is long in proportion to the length of the mesosternum. The ratio of the typical male manubrium to the mesosternum is as 2:5.3; in the female this ratio is as 3:4.2 (Strauch). In the present series, the ratio for the males is as 2.1:5; and that for the females is as 2.3:5.

There is sometimes a sternal foramen in the lower half of the mesosternum. When this foramen is present, it tends to increase the transverse diameter of the mesosternum. In the series of seventeen sterna two are thus perforate; but among the incomplete sterna in the collection there are four other examples with the perforation. Of the six perforate sterna two are male and four are female.

In two examples there is a complete fusion of the manubrium with the middle member (Pl. XLIII); both are males. In the entire collection there are three cases of fusion of the xiphisternum with the mesosternum. There is however a suggestion of cleavage across the front of one of these (cat. no. 282). (Pl. XLIII).

A sternal index as low as 22.6 is recorded in a female (cat. no. 813); and as high as 38.8 in a male (cat. no. 282).

HUMERUS

In the entire collection the adult humeri whole enough to admit of complete measurement number fifty-five. They comprise fourteen pairs and forty-one single humeri, representing thirty-three males, seventeen females, and five of doubtful sex. Of the fourteen paired humeri, eight belong to males and six to females. In ten of the fourteen paired humeri, the length-circumference dimensions of the right humeri average greater than those of the left humeri; in three the reverse is true; and in one there is no difference. This throws an interesting light on the problem of right-handedness and the bearing of the latter on the prevailing location of depressed fractures. Assuming that the larger right humerus means that the individual was right-handed, then

ten of the individuals were right-handed, three were left-handed, and one was probably ambidextrous. The ratio is approximately the same as that of depressed fractures on the left side of the head over those on the right side.

A left humerus may be absolutely smaller than the right of a pair, and yet have a higher index of robusticity or caliber index than its mate; so that caliber index is not a complete index of size. The largest caliber index in the series is 21.9, that of the right humerus in a male from Torontoy (cat. no. 775); the smallest, 16.6, is that of the left humerus of a female from Paucarcancha (cat. no. 299b). According to Martin this index has an extreme range between 25.2 and 16.6, including various races and both sexes. His maximum index is from a male Indian of California, the minimum from a Senoi female in Malacca. It will thus be seen that the index among the Peruvian highlanders covers only the lower half of the entire range.

A good deal has been written concerning the anomaly known as the perforation of the olecranon fossa. In the collection of fifty-five humeri the perforation of the left olecranon fossa occurs three times (in two males and one female); that of both right and left occurs but once, namely in no. 772, a very small adult female from Torontoy. In a few cases, the olecranon fossa comes so nearly being perforated as to be translucent.

There is no wide range of variation in the development of the coronoid fossa. With respect to the radial fossa, the case is somewhat different. In the great majority of humeri it is scarcely noticeable. In exceptional cases it may be almost as conspicuous as the coronoid fossa. A well-marked radial fossa is to be noted in twelve cases out of the total of fifty-five; of the twelve, seven are male and five female.

The cubital angle, is the angle formed by the axis of the humeral shaft and that of the trochlea. The value of this angle does not cover a very wide range. It is lowest (78.5) in a humerus of doutbful sex (cat. no. 573), and highest (90) in the pair of short, robust humeri (cat. no. 299) referred to elsewhere (see Pl. XIX).

The ratio that the length of the forearm bears to that of the upper arm is expressed by the radio-humeral index. This index reaches its minimum, 69.5 in a female (cat. no. 782); its maximum, 83.2, in a male (cat. no. 294).

RADIUS AND ULNA

Sixty-three radii and fifty-one ulnae were measured. There were

eleven paired radii and twelve paired ulnae. Among the paired radii, the linear measures of the right radii were greater than those of the left in seven cases; in two, they were smaller, and in two were the same as those of the left. An even greater preponderance in favor of the right holds true of the twelve paired ulnae, the right being greater in ten instances, less in one, and the same size as the left in one.

These ratios correspond approximately with what was noted from a comparison between the right and left of paired humeri; the upper arm bones averaged somewhat larger on the right side. This means evidently that a majority of the individuals in question were right-handed, proof of which is seen not only in the greater average size of the right arm but also in the fact that the number of fractures inflicted by right-handed blows is correspondingly greater than those inflicted by left-handed blows.

SACRUM

Of the fifty-two sacra in the collection that are complete enough to admit of measurement, twenty-six are male and twenty-two female; the sex of the remaining four cannot be determined with certainty. All the sacra are composed of the usual number of segments (five) with one exception, a female from Paucarcancha (cat. no. 295), which has only four segments (Pl. XLIII). There is however a lack of development of the alae in two of the five-segmented sacra. In a female from Paucarcancha (cat. no. 190), only the left ala is completely developed, while the right is reduced to the dimensions of an ordinary lumbar vertebral transverse process and does not even articulate with the wing of the second segment (Pl. XLIII). The body of the first segment is not fused with that of the second although the individual had reached the fully adult stage. This phenomenon can likewise be explained on the assumption that this first segment is the fifth lumbar instead and that we have here an example of unilateral lumbo-sacral synostosis. In a female from Torontoy (cat. no. 782), the left ala failed to develop and does not articulate with the wing of the second segment except for a small projection. The right ala is only partially developed and never fused with the wing of the second segment. Neither had the bodies of these two segments fused although the individual had reached the age of about fifty-five years (Pl. XLIII).

There is a tendency toward lack of fusion between the first and second segments in a number of sacra of both sexes. In three males this applies both to body and alae (cat. nos. 394, 627, 921); while in three

males and two females, it applies only to the body (cat. nos. 390, 439, 461, 1025, and 1026).

On the other hand there is quite a marked tendency toward a fusion of the first coccygial segment with the last sacral segment. The fusion is complete including body, transverse processes and horns, in nine males. In one male the body only of the first coccygial segment is fused with that of the last sacral. In two males, the fusion is between the transverse processes only; and in one male, both the transverse processes of the first coccygial segment and the body are fused with those of the last sacral segment. It is a remarkable fact that this tendency toward a fusion of the first tail bone with the sacrum should occur thirteen times among the twenty-six males and not once among the twenty-two females. Its frequency, (50%) among males is such as almost to make of it a sex character. There are of course good and sufficient reasons why the coccyx should articulate freely with the sacrum in the female, reasons which do not apply in case of the male.

Another sex distinction, and also one which the author has not seen noted elsewhere, is the degree of development of the median sacral crest. It is more pronounced in the male than in the female, the difference being often great enough to affect the size of the external sagittal diameter. The crest of the first segment is usually the most prominent portion. In rare cases among the males, the height of the first segment is maintained throughout the length of the total sacral crest (cat. no. 463). On the other hand the crest of the first segment is wholly lacking (cat. no. 461) in a female sacrum from Paucarcancha. In fact the neural arch is incomplete, failing to bridge the median gap by 7 mm. A median gap of 15 mm., occurs in the posterior arch of the first segment of a male sacrum from Patallacta (cat. no. 703). A somewhat broader hiatus occurs in the posterior arch of the first segment of a male sacrum from Torontoy (cat. no. 789). A similar gap is found in the posterior arch of the second segment only in the male sacrum from Huispang (Pl. XLIII).

Still more remarkable is the condition to be noted in another male sacrum from Patallacta (cat. no. 1029), which has no median sacral crest at all. The posterior arches of all five sacral segments are incomplete, so that the hiatus between the sacral horns of the fifth segment is continuous to the top of the first segment, as seen in Plate XLV. The sacrum is still in natural articulation with the rest of the pelvis and held in place by means of the dessicated ligaments.

A condition approaching the foregoing is found in a youthful sacrum,

probably male, from Patallacta (cat. no. 722). The hiatus is continuous throughout the length of the sacrum except in the region of the second segment.

In a sacrum of an adult female from Paucarcancha (cat. no. 461), the posterior arch of the first segment failed to develop (Pl. XLVI).

In dimensions the female sacra average, as usual, shorter and broader than the male sacra. The minimum straight-line male sacral length is 8.6, the maximum, 12.3 cm.; for the female sacra, the extremes are 7.6 and 10.7 cm., respectively. The extremes in breadth among the female sacra are 8.8 and 12.1 cm.; those among the male sacra are 9.9 and 12.1 cm. These extremes of breadth figures would seem to give the predominance to the male sacra, but in reality such is not the case.

It follows that the female indices are larger than those of the males. The smallest sacral index in the list of females is 105.1, the largest is 146.3. On the other hand, the extreme indices for the male sacra are 92.1 and 124.4.

The sex is doubtful in a sacrum and portion of the vertebral column of an adult from Paucarcancha (cat. no. 390). The body of the first segment had not fused with that of the second. There were two short ribs on the first lumbar vertebra, one of which is still in place (Pl. XLVI) The collection includes four other cases of ribs on the first lumbar vertebra. In five cases where no ribs had been attached, the transverse processes of the first lumbar vertebra were either small or rudimentary.

PELVIS

In regard to the pelvic girdle as a whole, there is little that need be added except that there is quite a wide range of variation in certain sex characters, such for example as the size of the pre-auricular groove, of the sub-pubic angle, and the angle formed by the great sciatic notch. There is also quite a wide range of variation in the size of, and the distance between the two pubic tubercles.

The maximum sub-pubic angle among the females is 81° and the minimum, 62°. Wide as this range is, it does not overlap on that of the males, which begins at 34° and stops with a maximum of 61°, just one short of the minimum among the females. The divergence between the sexes and within a given sex is equally great in reference to the size of the angle of the great sciatic notch. In a few males however, the angle of this notch attains to female size, as does likewise the pre-auricular groove;

so that these two characters alone are not absolutely sure guides in the determination of sex. The transverse diameter of the pelvic exit ranges from 6.1 to 9 cm. It overlaps appreciably on that for the females with a range of from 8.2 to 11 cm. The sagittal diameter of the pelvic exit among the males begins with a minimum of 7.2 cm., and ends with a maximum of 10.6 cm. The minimum of this measure among the females is 9.1 and the maximum 11.7 cm.

The female acetabular breadth ranges between 12.3 and 13.9 cm.; the male acetabular breadth is appreciably less (11.0–12.7 cm.). This relation holds true of the transverse diameter of the brim, the extremes for the females being 10.9 and 13.6 cm., those for the males, 10.9 and 13.0 cm., respectively. The relation is different in respect to the sagittal diameter of the brim. Here the female pelves furnish both the minimum (7.9 cm.) and the maximum (11.5 cm.). The male extremes fall between, being 8.2 and 11.3 cm., respectively.

The index of the pelvic brim varies from 62.2 in a female (cat. no. 301) to 88.4 in a male (cat. no. 862).

FEMUR

There are in the collection twenty-three pairs of femora and over one hundred unpaired femora that are complete enough to admit of measurement. In nearly all of these the sex has been determined. The measurements reveal a wide variation in certain features. The shortest femur (31.8 cm.) is that of a female from Paucarcancha (cat. no. 545); the longest femora belong to a male from Torontoy (cat. no. 780), each one being 43.8 cm., in length. In respect to torsion there is a wide divergence, the angle in one case being as low as —13°; the largest angle is +41° so that the total range is 54°.

There are features about the shaft that should be noted. Some of the femora are straight and round in section at the middle; others have a pronounced curvature and a well-developed pilaster or linea aspera. The pilaster itself may be practically wanting especially in the straight femora with round section. It may be prominent and rise to a single, almost sharp, crest line; or it may be a true pilaster with a breadth of 8 or 10 mm. These differences are reflected in the pilastric index, which drops as low as 86.9 and rises to a maximum of 136.4.

The shape of a cross section of the femur some 3 or 4 cm. below the small trochanter is subject to wide divergence. The ratio which the antero-posterior diameter bears to the transverse diameter at this level

is called the index of platymeria. The flatter the femur, the smaller the index and vice versa. The lowest index in the series is 54.8; the highest, 81.5.

The femur of most mammals possesses a third trochanter, to which is attached a portion of the gluteus maximus muscle. Wildbrand in 1843 was the first to note the presence of a third trochanter in man, where it is nearer to the grand trochanter than is the case among the mammals. In man this process likewise serves for the attachment of a portion of the musculus gluteus maximus and is hence homologous with the third trochanter in the lower mammals. The third trochanter is present in six femora of the Peruvian collection here described (Pl. XLVI).

The presence of a supra-condyloid crest above the median and lateral condyles at the knee is noted in several femora (Pl. XLVI).

STATURE

Manouvrier has given tables showing the correspondence of bone lengths among themselves and with the stature. The tables are from measures on the bones. There is one table for males and another for females; also mean coefficients for lengths shorter and lengths longer than those given in the tables. Manouvrier makes use of the six long bones.

The author failed to measure the fibula for lack of time, but the stature can be calculated from any one or all of the other five long bones. The shortest humerus in the collection measures 24.7 cm., and is that of a diminutive male of robust build (Pl. XIX). By adding 2 mm., and multiplying by the mean coefficient 5.25, one arrives at a stature for the living of 130.7 cm. The shortest ulna in the collection belongs to the same individual (cat. no. 299) and its physiological length is 18.4 cm. By adding 2 mm., and multiplying by the mean coefficient, the result obtained is 122.5 cm. The mean stature is therefore 126.1 cm. or about 4 feet 1.7 inches.

There are two male humeri (cat. nos. 370 and 523) that reach the maximum length of 31.7 cm. which corresponds to a stature of about 163.5 cm. The longest ulna, 23.9 cm., is that of a male (cat. no. 735) which corresponds with a height of 159 cm.

The minimum oblique femur length in the collection measures 31.4 cm., and is among the female femora. This corresponds with a stature on the living of 122.3 cm. or 4 feet 1 inch. The longest femur is that of

a male and measures 43.3 cm. which presupposes a stature of 164.2 cm., or 5 feet 4.6 inches.

The shortest tibia, that of a male, has a condylo-astragaloid length of 25.2 cm. which points to the remarkably low stature of 121.9 cm. or just short of 4 feet (cat. no. 460). The longest tibia in the collection was excluded from the tables because the shaft was enlarged through disease. Its length however was taken, and measured 35.3 cm. which is correlated with a height of about 160 cm. or 5 feet 3 inches.

From the foregoing and from the appended tables, it is evident that the Peruvian highlanders were relatively low of stature, with a range of from 121.9 to 164.2 cm., or from 4 feet to about 5 feet, 4½ inches.

MEASUREMENTS

The measurements employed are those that have been approved by the International Commissions of Monaco (1906) and of Geneva (1912)[1], in so far as the measures have been covered by these Commissions. In other cases the author has followed the lead of such men as Hrdlička in this country, and Martin, now at Munich. The index of platycnemia is taken from the two diameters at the middle of the shaft instead of at the level of the nutritive foramen.

For indices the following formulae have been used:

Cranium:

$$\text{Cephalic index } \frac{\text{breadth x 100}}{\text{length}}$$

$$\text{Height-length index} = \frac{\text{basi-bregmatic height x 100}}{\text{length}}$$

$$\text{Height-breadth index} = \frac{\text{basi-bregmatic height x 100}}{\text{maximum breadth}}$$

$$\text{Upper facial index} = \frac{\text{nasion-prosthion diameter x 100}}{\text{bizygomatic diameter}}$$

$$\text{Orbital index} = \frac{\text{height x 100}}{\text{breadth}}$$

$$\text{Nasal index} = \frac{\text{breadth x 100}}{\text{length}}$$

$$\text{Index of palate} = \frac{\text{breadth x 100}}{\text{length}}$$

[1]Given in English in Hrdlicka's *Anthropology*, 80, Wistar. Int., Phila., 1921. See also G. G. MacCurdy, *Science*, N. S., xxxvi, 603, Nov. 1, 1912.

Scapula:

$$\text{Scapular index} = \frac{\text{morphological length x 100}}{\text{morphological breadth}}$$

$$\text{Infraspinous index} = \frac{\text{infraspinous length x 100}}{\text{morphological breadth}}$$

Sternum:

$$\text{Sternal index} = \frac{\text{maximum breadth of mesosternum x 100}}{\text{sternal length (not including the xiphisternum)}}$$

Humerus:

$$\text{Caliber index (Index of robusticity)} = \frac{\text{minimum circumference x 100}}{\text{maximum length}}$$

Radius:

$$\text{Caliber Index} = \frac{\text{minimum circumference x 100}}{\text{physiological length}}$$

$$\text{Radio-humeral index} = \frac{\text{maximum length of radius x 100}}{\text{maximum length of humerus}}$$

Ulna:

$$\text{Caliber index} = \frac{\text{minimum circumference x 100}}{\text{physiological length}}$$

Lumbar Vertebrae:

$$\text{Vertebral index} = \frac{\text{posterior vertical diameter x 100}}{\text{anterior vertical diameter}}$$

$$\text{Lumbo-vertebral index} = \frac{\text{sum of posterior measures x 100}}{\text{sum of anterior measures}}$$

Sacrum:

$$\text{Sacral index} = \frac{\text{maximum breadth x 100}}{\text{straight-line length}}$$

Pelvis:

$$\text{Breadth-height index} = \frac{\text{height x 100}}{\text{breadth}}$$

$$\text{Index of brim} = \frac{\text{sagittal diameter of brim x 100}}{\text{transverse diameter of brim}}$$

Femur:

$$\text{Pilastric index} \quad \frac{\text{antero-posterior diameter at middle x 100}}{\text{transverse diameter at middle}}$$

$$\text{Caliber index} = \frac{\text{circumference at middle x 100}}{\text{oblique length}}$$

$$\text{Index of platymeria} = \frac{\text{upper antero-posterior diameter x 100}}{\text{upper transverse diameter}}$$

$$\text{Humero-femoral index} = \frac{\text{humeral length x 100}}{\text{oblique length of femur}}$$

Tibia:

$$\text{Index of platycnemia} = \frac{\text{transverse diameter at middle x 100}}{\text{antero-posterior diameter at middle}}$$

General Summary

The skeletal remains come from eight localities in the highlands to the northwest of Cuzco.

The burial customs were the same in all. Natural caves and rock shelters were utilized as communal burial places. Boulders were also made to serve as shelters for one or more skeletons. The same burial customs prevailed throughout the highlands of Peru as well as of Ecuador according to published reports of Hrdlička (central and southern Peru); G. F. Eaton (Machu-Picchu) and P. Rivet (Paltacalo). The big cave at Paucarcancha contained over 200 skeletons.

The mummies were originally put away in a sitting posture. This is indicated not only by the attitude the mummy was forced into before and during the process of wrapping, but also by the presence of seat rings composed of withes twisted and held in place by strips of bark and cords. Arms and legs were sharply flexed, the wrists against the chest and the ankles tightly together and against the pubic arch. The mummy wrappings for the most part consisted of coils of coarse grass rope; these coils were sewn together by means of grass cords. Cloth of a coarse, as well as a fairly fine variety, was also found with some of the mummies.

The Aymara type of artificial cranial deformation was met with in all but one of the localities. Out of a total of 341 crania, 147 were thus deformed. In only a very few crania was there even a suspicion of the coastal or occipito-frontal type of deformation. The collection includes also a few crania that were unintentionally deformed.

A slight Aymara deformation has practically no effect on the cephalic index of the cranium; it is also to be noted that the crania with lowest cephalic index are the undeformed ones.

Since the discovery of the remains of what was supposed to be a paleo-American race at Lagoa Santa (Brazil) in 1843, anthropologists have been rewarded by the finding of the Lagoa-Santa type in other parts of South America. Rivet found examples of this type in the

region of Paltacalo (Ecuador), and the skulls he reproduced as typical could be duplicated in the collection here under study. In this collection there are 29 crania with the Lagoa-Santa range of cephalic index (as well as other characteristics) and they form a fairly homogeneous group.

Humboldt, Collineau and Daveluy, von den Steinen, and Kollmann have all mentioned the existence of a pygmy race in South America. In the collections from the Peruvian highlands there are small statures that might suggest the presence of a pygmy type, but the evidence does not support the assumption that these represented any more than variation of the generally low stature of the people whose remains have been here considered.

The collection is remarkable for the high percentage of trephined crania it comprises. Eliminating skulls represented by small fragments and those of very young children, out of the 273 remaining crania, 47 or 17 per cent have undergone at least one trephining operation. But some of the skulls were operated on more than once (one to five times), so that the percentage of operations to the total number of skulls was even greater. This is all the more remarkable when it is recalled that out of a collection of some 135 crania from Machu Picchu only eight miles in a straight line from Torontoy, not a single case of trepanation has been reported. But at Machu Picchu, females predominated; while throughout the region represented by the collection under consideration, the males predominate.

A study of the position of the fractures and of the trephining operations, leads to the conclusion that the high percentage of both marks a period of warfare among the Incas of the region in question. Among barbaric as well as civilized races a majority of both sexes are right-handed. In combat, the left side of the head would be exposed to danger more often than the right, and it was precisely the left side that suffered most in the series, if we eliminate those in which the external table only was removed (partial trepanation).

In brief, the burial caves of the Peruvian highlands appear to represent a period of strife, a period which tended to develop the art of surgery. In rare instances the flint knife was employed to remove diseased bone. The operation was plainly for the purpose of relieving depressed fractures in some 28 per cent of the cases. In the rest the operation either obliterated all trace of its cause, or else the cause was not of such a nature as to affect the osseous system. The stone war club with stellate points was doubtless the weapon that accounted for many of the depressed fractures.

Traumatism was by no means confined to fractures of the skull. The infra-orbital region bears marks of combat in a number of cases. There are also examples of fractured arm and leg bones, as well as injuries causing fusion of the joints.

There was one case where it was obvious that trephining had for its purpose the removal of diseased bone.

A notable pathologic example is the skull of an adult male with a large osteophytic excrescence due to osteosarcoma.

Several crania as well as long bones of both adults and children bear marks of having suffered from possibly syphilitic necrosis. One skeleton has been much altered in weight by osteomalacia.

Arthritis in various forms was a common disease. Arthritis deformans, producing a mushroom head to the femur and affecting the sockets in a corresponding manner, was not rare, and spondylitis deformans, affecting the vertebrae was fairly common in the older people. Several cases of periostitis and osteoperiostitis were noted.

Of the 149 undeformed or but slightly deformed crania measured, 89 are mesocephalic, 50 dolichocephalic, and 10 brachycephalic. The lowest index is 69.7 and the highest 82.9. The smallest cranium has a capacity of 1020 c.c., the largest 1670 c.c. The sutures vary in pattern from very simple to highly complex. In 9 per cent. of the crania the metopic suture has persisted. The squamo-mastoid suture has remained open in about 10 per cent. of the crania that represent an age of more than two years. There are but six examples of the true Inca bone in the entire collection.

No examples of supernumerary teeth were noted. The retention of milk teeth occurred in twelve cases and in every case but one caused displacement or suppression of some tooth of the permanent dentition. The milk tooth most often retained was the canine. There are two cases of delayed eruption of teeth without the presence of any visible evidence as to the cause of the retardation.

Tooth morbidity and loss in life was high. In 12 jaws out of 422, the teeth had all disappeared prior to decease of the individual. In a majority at least some of the teeth had been lost during life. Of the teeth still in situ a surprising percentage were decayed. Pyorrhea affected more than 13 per cent. of all the jaws. Alveolar abcesses were present in 22 cases, bone cists in 10, caries of the jaw in 6, and maxillary necrosis in 1. The formation of tartar was noted in 13 cases.

All of the 52 sacra have the usual number (five) of segments with the exception of one female which had only four. A tendency toward lack

of fusion between the first and second segments was noted in a number of sacra, (this applies to both body and alae), and in two instances an ala failed to develop. On the other hand there was a marked tendency toward a fusion of the first coccygial segment with the last sacral segment, being noted in 13 of 26 males, but not once among 22 females. Another sex distinction observed was in the degree of development of the posterior median sacral crest. It was more pronounced in the males than in the females; one male had no crest at all.

The ancient Peruvian highlanders were of relatively low stature, the range, estimated from the long bones, being from 121.9 to 164.2 cm.

For details of measurements of the crania and bones see tables.

TABLE I

Catalogue Number	Approximate Age Deformation[1]	Length	Breadth	Cephalic Index	Basi-Bregmatic Height	Height-Length Index	Height-Breadth Index	Capacity	Maximum Circumference	Nasion-Opisthion Arc	Thickness of Left Parietal	Nasion Prosthion	Maximum Bizgomatic Diameter	Upper Facial Index	Minimum Frontal Diameter	Breadth of Orbits (R· & L.)	Height of Orbits
PAUCARCANCHA																	
♂ 3	40sl.	17.2	13.5	78.5	13.3	77.3	98.5	1330	47.8	35.3	0.5	6.7	13.1	51.1	9.2	3.5 3.5	3.8 3.7
4	30	18.3	12.8	69.9	13.0	71.0	101.6	1305	50.3	36.6	0.5	6.4	12.8	50.0	9.1	3.6 3.6	3.5 3 6
8	45	18.6	13.5	72.6	13.5	72.6	100.0	1485	50.5	37.7	0.4	6.5	13.8	47.1	8.9	3.6 3.7	3.6 3.8
10	40	18.4	13.5	73.4	13.7	74.4	101.5	1500	50.6	37.6	0.6	6.3	13.6	46.3	9.3	3.7 3.6	3.5 3.5
12	45	18.2	12.7	69.8	13.2	72.5	103.9	1290	49.3	35.3	0.4	7.7	13.7	56.1	8.8	3.8 3.7	3.6 3.6
14	60	18.0	13.8	76.7	13.6	75.5	98.5	1340	50.3	36.6	0.5	6.6	13.9	47.5	9.6	3.6 3.7	3.5 3.5
16	60sl.	17.6	13.4	76.1	14.0	79.5	104.5	1355	48.7	36.7	0.5	7.3	13.7	53.3	10.2	3.8 3.7	4.0 4.0
17	80	17.8	13.6	76.4	13.6	76.4	100.0	1310	49.6	36.0	0.7	6.2	——	——	9.8	3.8 3.8	3.3 3.4
21	60	18.0	14.0	77.8	14.0	77.8	100.0	1470	50.8	36.1	0.6	——	——	——	9.2	—— ——	—— ——
22	55sl.	16.9	13.4	79.3	14.0	82.8	104.5	1200	46.8	34.8	0.5	——	——	——	8.4	—— ——	—— ——
24	60	18.7	14.0	7.49	14.0	74.9	100.0	1430	51.6	36.9	0.6	7.1	——	——	9.5	4.0 4.0	3.8 3.7
26	20	17.3	13.9	80.3	13.7	79.2	98.6	1420	48.3	36.9	0.6	5.6	12.2	45.9	8.7	3.4 3.4	3.1 3.0
28	50	17.6	13.4	76.1	13.9	78.9	103.7	1390	48.8	36.3	0.6	——	12.9	——	9.4	3.9 3.9	3.7 3.7
30	30sl.	17.5	13.2	75.4	13.2	75.4	100.0	1330	48.0	36.0	0.4	6.6	13.4	49.2	9.0	3.8 3.7	3.5 3.5
33	28sl.	17.6	13.7	77.8	13.5	71.0	98.5	1340	48.6	35.0	0.5	7.1	13.9	51.1	9.1	4.0 4.0	3.9 3.9
34	60	18.8	13.6	72.3	14.3	76.1	105.1	——	51.4	——	0.8	6.9	13.7	50.4	9.1	3.7 3.6	3.3 3.3
36	75sl.	18.0	13.0	72.2	14.0	77.8	107.7	1395	49.2	36.9	0.5	——	——	——	8.5	—— 3.4	—— 3.5
37	40	17.9	13.1	73.2	13.4	74.9	102.3	1368	49.0	37.1	0.5	6.4	13.2	48.5	8.9	3.8 3.7	3.5 3.5
40	65	17.8	13.4	75.3	13.8	77.5	102.9	1354	49.6	36.2	0.7	6.8	14.2	47.9	9.2	3.5 3.5	3.7 3.6
41	40sl.	17.8	13.6	76.4	14.1	79.2	103.7	1465	49.4	36.9	0.7	8.0	13.6	58.8	9.3	3.7 3.7	3.7 3.7
44	28	17.2	13.0	75.6	13.7	79.6	105.4	1240	47.6	35.8	0.6	7.1	13.3	53.8	8.6	3.7 3.8	3.6 3.6
46	65	17.2	14.1	82.0	13.6	79.1	96.4	1350	48.0	36.0	0.5	6.9	13.4	51.5	8.4	3.6 3.6	3.6 3.6
47	24sl.	16.5	12.9	78.2	14.0	84.8	108.5	1310	——	35.6	0.5	6.6	12.7	51.9	8.5	3.4 3.4	3.5 3.5
48	45	17.5	12.8	73.1	13.7	78.3	107.0	1315	47.8	35.5	0.4	7.3	13.6	53.7	9.2	3.9 3.8	3.4 3.4
49	60	17.1	12.7	74.3	12.0	70.2	94.5	1250	48.4	36.2	0.8	——	12.9	——	9.3	3.4 3.4	3.5 3.4
55	45	17.8	13.6	76.4	14.0	78.6	102.9	1416	50.0	38.2	0.7	6.8	14.0	48.6	9.8	3.8 3.8	3.5 3.5
57	40	17.8	——	——	12.8	71.9	——	——	——	36.4	0.4	6.2	13.5	45.2	8.8	3.8 3.8	3.5 3.5
59	38	18.3	13.5	73.8	14.0	77.1	103.7	1440	50.3	37.7	0.5	6.4	13.0	49.2	8.9	3.7 3.6	3.1 3.1
60	50	18.4	13.5	73.4	14.5	78.8	107.4	1470	50.5	38.3	0.6	——	13.6	——	9.6	3.7 3.8	3.5 3.5
63	30sl.	17.0	13.2	77.6	13.0	76.5	98.5	1210	47.4	34.6	0.4	6.5	12.5	52.8	8.6	3.7 3.5	3.7 3.6
65	25	17.2	13.5	78.5	14.3	83.7	105.9	1400	48.1	35.0	0.4	6.9	13.9	49.6	9.8	3.9 3.9	3.6 3.6
66	38	17.7	13.0	73.4	13.4	75.7	103.1	1260	48.6	35.9	0.5	6.6	——	——	8.8	3.4 3.4	3.3 3.3
69	70sl.	——	——	——	——	——	——	1500	——	39.2	0.4	6.7	13.6	49.3	8.8	3.6 3.7	3.5 3.6
75	20	17.2	13.4	77.9	13.6	79.1	101.5	1450	48.0	36.2	0.3	6.3	13.1	48.1	9.4	3.8 3.8	3.8 3.8

[1]sl = slight, moderate
pr = pronounced

CRANIA

Orbital Index	Length of Nose	Breadth of Nose	Nasal Index	Basion to Sub-nasal Point	Breadth between Orbits	Basion to Prosthion	Basion to Akanthion	Basion to Nasion	Prosthion to Nasion	Prosthion to Akanthion	Facial Angle	Alveolar Angle	Length of Palate	Breadth of Palate	Index of Palate	Prosthion to Sub-nasal Point	Mean Diameter of Foramen Magnum	Dental Arch Length	Dental Arch Breadth
108.6 105.7	4.7	2.5	53.2	8.6	2.8	9.6	9.2	9.4	6.7	2.1	68.0	56.0	4.2	4.0	95.2	2.0	3.3	5.0	6.5
97.2 100.0	4.6	2.3	50.0	8.5	2.4	9.2	8.8	9.6	6.4	2.2	67.5	60.0	4.2	4.1	97.6	2.1	3.3	5.0	6.3
100.0 102.7	4.8	2.4	50.0	8.2	2.4	9.2	8.8	9.9	6.5	1.9	75.5	53.0	4.5	3.9	86.7	1.9	3.1	5.1	6.6
94.6 97.2	4.5	2.1	46.7	9.1	2.2	9.7	9.6	9.6	6.3	2.0	70.0	64.5	4.3	3.7	86.0	1.8	3.7	5.0	6.0
94.7 97.3	5.7	2.5	43.9	9.4	2.2	10.1	10.0	10.4	7.7	2.0	70.0	62.0	4.5	4.3	95.5	2.0	3.3	5.3	6.6
97.2 94.6	4.8	2.2	45.8	8.4	2.2	9.3	9.2	9.6	6.6	1.8	72.0	55.0	4.5	4.3	95.5	1.8	3.5	5.0	6.2
105.3 108.1	5.2	2.5	48.1	8.6	3.0	9.4	9.3	10.1	7.3	2.4	73.0	62.5	4.1	4.0	97.6	2.2	3.2	4.5	6.2
86.8 89.5	4.7	2.4	51.1	8.8	2.6	9.9	9.6	9.8	6.2	1.7	71.5	45.5	—	—	—	1.5	3.4	—	—
— —	—	—	—	—	2.6	—	—	10.0	—	—	—	—	4.5	4.5	100.0	—	3.6	—	—
— —	—	—	—	—	—	—	—	9.6	—	—	—	—	—	—	—	—	3.4	—	—
95.0 92.5	5.2	2.5	48.1	9.1	2.4	9.8	9.8	10.3	7.1	2.0	73.0	62.5	4.7	4.1	87.2	1.9	3.1	5.0	—
91.2 88.2	4.2	2.3	54.8	8.4	2.2	9.1	8.6	9.0	5.6	1.7	71.0	58.0	4.5	4.0	88.9	1.6	3.1	4.8	6.5
94.9 94.9	5.0	2.5	50.0	8.9	2.2	—	9.3	10.2	—	—	—	—	—	—	—	—	2.9	—	—
92.1 94.6	4.5	2.6	57.8	9.0	2.7	9.8	9.4	9.5	6.6	2.3	67.0	61.0	4.4	4.0	90.9	2.1	3.3	5.2	6.3
97.5 97.5	5.0	2.4	48.0	9.0	2.2	9.1	9.6	10.1	7.1	2.2	76.0	82.0	4.5	4.0	88.9	2.2	3.5	5.2	6.6
89.2 91.7	5.0	2.4	48.0	9.1	2.7	9.7	9.6	9.9	6.9	1.9	71.0	65.0	4.5	4.1	91.	1.9	3.8	5.2	—
— 102.9	5.2	—	—	8.6	—	—	9.0	9.5	—	—	—	—	—	—	—	—	3.3	—	—
92.1 94.6	4.7	2.4	51.1	8.3	2.2	8.9	9.0	9.7	6.4	1.7	77.0	63.5	4.4	3.9	88.6	1.6	3.1	5.1	6.4
105.7 102.8	5.1	2.5	49.0	8.6	2.7	9.2	9.1	9.8	6.8	1.7	73.5	64.5	4.6	—	—	1.7	3.6	—	—
100.0 100.0	5.3	2.6	49.1	8.6	2.6	9.6	9.3	10.1	8.0	2.7	69.5	60.0	4.6	4.0	86.9	2.6	3.1	5.3	6.2
97.3 94.7	5.1	2.3	45.1	8.1	2.1	8.7	8.8	9.6	7.1	2.1	74.0	65.	4.1	4.4	107.3	1.9	3.2	5.0	6.8
100.0 100.0	5.0	2.5	50.0	8.4	2.1	9.2	8.9	9.2	6.9	2.0	68.0	59.0	4.6	—	—	1.9	2.9	5.3	—
102.9 102.9	5.0	2.4	48.0	8.5	2.2	9.4	9.0	9.6	6.6	1.8	71.0	57.0	4.3	3.9	90.7	1.8	3.1	5.1	6.0
87.2 89.5	4.7	2.3	48.9	8.9	2.4	10.0	9.7	10.2	7.3	2.6	69.0	56.0	4.7	4.2	89.4	2.6	3.4	5.3	6.5
102.9 100.0	5.2	2.4	46.1	8.3	2.8	—	8.7	9.2	—	—	—	—	—	—	—	—	2.9	—	—
92.1 92.1	4.9	2.3	46.9	8.4	2.6	9.3	9.1	9.5	6.8	2.3	70.5	58.0	4.4	3.6	81.8	2.0	3.0	5.2	6.3
92.1 92.1	4.6	2.4	52.2	8.4	2.5	9.0	8.8	9.1	6.2	1.7	71.0	64.0	4.3	—	—	1.7	3.1	5.1	—
83.8 86.1	4.6	2.8	60.9	8.8	2.6	9.3	9.3	9.7	6.4	1.9	75.0	73.0	4.2	4.1	97.6	1.9	3.2	4.8	6.4
94.6 92.1	4.8	2.6	54.2	8.4	2.8	9.2	9.2	9.8	6.5	—	75.0	59.0	—	—	—	1.8	3.3	—	—
100.0 102.8	4.9	2.4	48.9	8.7	2.1	9.4	9.4	9.3	6.5	1.9	68.5	61.5	4.3	3.7	86.0	1.8	3.1	5.5	6.0
92.3 92.3	4.9	2.7	55.1	9.6	2.5	10.5	10.0	10.5	6.9	2.2	70.5	59.0	4.6	4.5	97.8	2.1	3.5	5.7	7.3
97.1 97.1	4.8	2.3	47.9	8.8	2.3	9.7	9.4	9.8	6.6	1.7	71.0	57.0	4.7	3.8	80.8	1.7	3.1	5.2	6.1
97.2 97.3	5.0	2.3	46.0	9.0	2.3	9.6	9.6	10.0	6.7	1.7	73.5	65.0	4.4	—	—	1.6	3.1	5.1	—
100.0 100.0	4.3	2.4	55.8	9.0	2.4	10.0	9.5	9.7	6.3	2.1	68.5	55.0	4.2	3.9	92.9	2.0	3.4	5.4	6.4

Catalogue Number	Approximate Age Deformation.	Length	Breadth	Cephalic Index	Basi-Bregmatic Height	Height-Length Index	Height-Breadth Index	Capacity	Maximum Circumference	Nasion-Opisthion Arc	Thickness of Left Parietal	Nasion Prosthion	Maximum Bizygomatic Diameter	Upper Facial Index	Minimum Frontal Diameter	Breadth of Orbits (R. & L.)	Height of Orbits
♂79	60sl.	17.9	13.6	76.0	14.0	78.2	102.9	1340	49.7	37.2	0.7	7.1	——	——	9.6	3.7 3.6	3.5 3.4
81	65	17.8	13.2	74.2	13.8	77.5	104.5	1380	49.3	36.3	0.4	7.1	——	——	9.6	—— 4.1	3.4 3.5
84	60	——	——	——	——	——	——	1110	——	34.8	0.4	5.6	12.0	46.7	8.0	3.5 3.4	3.1 3.2
85	65sl.	17.4	13.3	76.4	13.3	76.4	100.0	1300	48.5	36.6	0.5	6.5	12.7	51.2	9.0	3.6 3.5	3.3 3.3
87	55	18.8	13.8	73.4	14.6	77.7	105.8	1530	51.4	38.0	0.5	7.2	14.2	50.7	9.5	3.7 3.6	3.6 3.6
88	75sl.	——	——	——	——	——	——	1210	——	35.2	0.4	6.7	12.6	53.2	8.9	3.7 3.7	3.4 3.5
91	45sl.	16.8	12.2	72.6	13.2	78.6	108.2	1115	45.8	35.3	0.5	6.3	12.0	52.5	8.4	3.5 3.4	3.1 3.1
92	75sl.	17.5	13.4	76.6	13.6	77.7	101.5	1260	48.3	35.5	0.4	6.9	14.2	48.6	9.6	3.6 3.6	3.5 3.6
94	50sl.	——	——	——	——	——	——	1370	——	36.2	0.4	6.1	——	——	8.6	3.3 3.3	3.3 3.3
96	60sl.	——	——	——	——	——	——	1400	——	38.5	0.4	6.6	12.2	54.1	9.0	3.5 3.4	3.5 3.5
97	50sl.	——	——	——	——	——	——	1260	——	36.1	0.4	6.4	12.5	57.2	8.5	3.4 3.4	3.6 3.6
106	75	17.8	12.8	71.9	13.4	75.3	104.7	1280	48.5	36.4	0.6	6.6	13.0	50.8	9.4	3.8 3.8	3.6 3.5
107	65pr.	——	——	——	——	——	——	1480	——	38.0	0.4	——	13.7	——	9.6	3.5 3.6	3.5 3.5
112	70sl.	——	——	——	——	——	——	1330	——	36.2	0.4	——	13.2	——	8.8	3.7 3.7	3.6 ——
115	75	17.7	13.2	74.6	14.1	79.7	106.8	1380	48.3	35.5	0.4	7.4	13.5	54.8	9.1	3.7 3.6	3.6 3.6
118	24sl.	17.3	13.8	79.8	13.6	78.6	98.5	1375	48.2	36.1	0.5	6.4	13.2	48.6	9.4	3.6 3.6	3.6 3.5
119	60sl.	18.0	13.8	76.7	13.5	75.0	97.8	1350	49.6	36.7	0.4	6.4	13.9	46.0	9.4	3.7 3.7	3.6 3.6
122	20sl.	16.8	12.8	76.2	13.0	77.4	101.6	1270	46.7	35.7	0.4	6.6	12.6	52.4	9.0	3.6 3.6	3.3 3.3
123	21	——	——	——	——	——	——	1260	——	34.6	0.4	6.4	13.1	48.8	9.0	3.7 3.7	3.6 3.5
125	70	18.0	14.0	77.8	14.6	81.1	104.3	1595	51.2	37.0	0.4	7.2	——	——	10.0	3.9 3.8	3.3 3.2
126	30sl.	17.8	13.5	75.8	14.1	79.2	104.4	1350	48.6	37.2	0.5	6.7	12.8	52.3	9.0	3.5 3.6	3.3 3.2
127	60	18.2	13.4	73.6	14.0	76.9	104.5	1360	50.4	36.6	0.4	6.3	14.4	43.7	9.8	3.8 3.8	3.6 3.5
129	55	17.0	13.3	78.2	12.9	75.9	96.9	1211	46.6	34.4	0.4	6.9	13.2	52.3	8.9	3.6 3.5	3.4 3.3
142	70sl.	——	——	——	——	——	——	1210	——	35.5	0.4	6.9	13.7	50.4	8.7	3.7 3.6	3.5 3.5
151	55sl.	——	——	——	——	——	——	1310	——	35.8	0.6	6.9	13.0	53.1	8.6	3.6 3.5	3.5 3.5
160	26	17.6	13.0	73.9	13.6	77.3	104.6	——	48.0	37.3	0.4	6.8	12.3	55.3	9.2	3.8 3.4	3.6 3.7
161	28sl.	——	——	——	——	——	——	1440	——	36.6	0.4	6.4	13.1	48.8	9.0	3.4 3.4	3.2 3.2
174	70sl.	——	——	——	——	——	——	1388	——	37.1	0.4	7.2	13.7	52.5	9.0	3.9 3.8	—— 3.9
182	23	18.8	13.3	70.7	14.0	74.5	105.0	——	50.7	36.3	0.4	6.7	13.2	50.7	9.4	3.5 3.4	3.3 3.3
189	40sl.	18.0	13.6	75.6	14.1	78.3	103.7	1450	49.3	36.3	0.4	6.7	13.4	50.0	9.3	3.6 3.6	3.4 3.4
♀ 1	25pr.	17.6	12.8	72.7	12.5	71.0	97.7	1245	48.8	35.5	0.6	5.5	12.5	44.4	9.1	3.7 3.5	3.1 3.4
2	40	16.6	12.9	77.7	12.0	72.3	93.0	1140	46.3	35.0	0.5	6.1	12.3	49.6	8.6	3.7 3.6	3.3 3.2
6	28	17.2	12.8	74.4	13.0	75.6	101.6	1265	48.0	37.1	0.7	5.6	11.5	48.7	8.2	3.2 3.4	3.1 3.2
9	35	16.4	13.0	79.3	13.0	79.3	100.0	1260	46.0	34.9	0.3	6.9	12.8	53.9	8.1	3.7 3.7	3.4 3.6
13	40	16.5	13.0	78.8	13.5	81.8	103.8	1250	46.7	36.0	0.6	6.2	12.3	50.4	9.6	3.4 3.4	3.6 3.6

Orbital Index	Length of Nose	Breadth of Nose	Nasal Index	Basion to Sub-nasal Point	Breadth between Orbits	Basion to Prosthion	Basion to Akanthion	Basion to Nasion	Prosthion to Nasion	Prosthion to Akanthion	Facial Angle	Alveolar Angle	Length of Palate	Breadth of Palate	Index of Palate	Prosthion to Sub-nasal Point	Mean Diameter of Foramen Magnum	Dental Arch Length	Dental Arch Breadth
94.6 94.4	4.9	2.4	48.9	9.0	2.4	9.8	9.8	9.9	7.1	2.3	70.0	63.0	4.6	4.2	91.3	2.2	3.0	5.5	—
— 85.4	5.2	2.6	50.0	8.8	2.6	9.6	9.3	10.2	7.1	2.1	73.5	61.0	4.5	3.9	86.7	2.0	3.0	5.2	6.4
88.6 94.1	4.3	2.2	51.2	8.4	2.2	9.0	8.9	9.2	5.6	1.7	73.0	61.0	4.2	4.1	97.6	1.6	2.9	5.0	—
91.7 94.3	4.7	2.6	55.3	8.5	2.6	9.3	9.2	9.9	6.5	2.1	75.0	59.5	4.5	3.6	80.0	1.9	3.0	5.2	6.0
97.3 100.0	5.2	2.4	46.0	9.6	2.9	10.3	10.3	10.5	7.2	2.2	71.0	63.0	4.8	4.4	91.7	1.9	3.5	5.5	6.9
91.9 94.6	5.0	2.4	48.0	9.2	2.7	9.6	9.4	9.7	6.7	1.9	70.0	70.0	4.4	—	—	1.7	3.0	5.1	—
88.6 91.2	4.5	2.2	48.9	8.4	2.1	9.0	8.8	9.1	6.3	1.9	70.0	65.0	4.0	3.6	90.0	1.8	3.8	4.9	5.7
97.2 100.0	5.0	2.7	54.0	9.0	2.8	9.6	9.5	10.2	6.9	2.1	74.0	65.0	4.6	4.3	93.5	1.9	3.1	5.0	6.6
100.0 100.0	4.4	2.5	56.8	8.4	2.4	9.0	8.9	9.3	6.1	1.7	73.5	59.5	4.2	—	—	1.7	3.3	4.7	5.9
100.0 102.9	4.6	2.3	50.0	8.3	2.5	9.0	8.8	9.3	6.6	2.2	71.0	62.5	4.5	—	—	1.9	2.9	—	—
105.9 105.9	4.9	2.2	44.9	8.2	2.3	8.9	8.6	9.4	6.4	1.6	73.0	60.0	4.2	—	—	1.6	3.3	—	—
94.7 92.1	4.7	2.6	55.3	9.0	2.3	10.0	9.7	9.8	6.6	1.9	69.0	55.0	4.8	—	—	1.9	3.3	5.5	—
100.0 97.2	4.5	2.6	57.8	8.9	2.7	—	9.4	9.4	—	—	—	—	—	—	—	—	2.9	—	—
97.3	5.0	2.3	46.0	8.2	2.5	—	8.8	9.7	—	—	—	—	—	—	—	—	3.5	—	—
97.3 100.0	5.3	2.6	49.1	9.1	2.5	9.9	9.5	10.2	7.4	2.4	70.0	63.5	4.6	—	—	2.2	3.2	5.0	—
100.0 97.2	4.6	2.4	52.2	8.4	2.5	9.4	9.0	9.6	6.4	1.8	72.0	50.0	4.3	4.1	95.3	1.7	3.3	5.0	6.3
97.3 97.3	4.8	2.5	52.1	8.7	2.5	9.4	9.1	9.6	6.4	1.8	72.0	60.0	5.0	—	—	1.6	3.2	5.4	—
91.7 91.7	4.8	2.4	50.0	8.4	2.5	9.1	9.0	9.7	6.6	1.8	74.0	61.0	4.3	4.2	97.7	1.7	3.4	5.1	6.8
97.3 94.6	4.6	2.3	50.0	9.6	2.6	10.7	10.3	10.2	6.4	2.0	68.5	54.0	4.9	3.6	73.5	2.0	3.4	5.4	6.4
84.6 84.2	5.3	2.5	49.1	9.0	2.5	9.8	9.5	10.5	7.2	2.0	74.0	61.0	4.7	—	—	2.1	3.3	5.4	—
94.3 88.9	4.7	2.4	51.1	8.8	2.4	9.7	9.6	10.0	6.7	2.1	72.5	59.0	4.7	4.1	87.2	2.0	3.1	5.5	6.3'
94.7 92.1	4.8	2.5	52.1	9.6	2.4	10.1	10.1	10.7	6.3	1.8	77.5	69.0	—	—	—	1.7	3.1	—	6.4
94.4 94.3	5.0	2.2	44.0	9.0	2.0	10.0	9.7	9.2	6.9	2.0	63.0	55.0	4.8	3.6	78.0	2.0	3.0	5.5	6.3
94.6 97.2	5.0	2.4	48.0	9.2	2.2	10.0	9.9	10.2	6.9	1.9	72.0	55.0	4.7	3.8	80.9	1.9	3.3	5.0	6.1
97.2 100.0	5.1	2.5	49.0	8.8	2.4	9.8	9.6	10.0	6.9	2.0	71.0	53.0	4.8	—	—	1.9	3.1	5.4	—
94.7 108.8	5.0	2.4	48.0	8.4	2.6	9.7	9.0	9.5	6.8	2.1	68.0	49.0	4.7	4.0	85.1	2.2	3.3	5.3	6.2'
94.1 94.1	4.7	2.6	55.3	8.6	2.5	9.4	9.2	9.5	6.4	1.7	71.0	58.0	4.5	4.1	91.1	1.7	3.2	5.1	6.3
— 102.6	5.3	2.5	47.2	8.8	2.0	9.8	9.4	10.0	7.2	1.9	70.0	54.0	4.7	4.4	93.6	1.9	3.3	5.1	6.8
94.3 97.1	5.0	2.6	52.0	9.7	2.6	10.3	10.3	10.4	6.7	1.8	72.0	65.5	4.5	4.0	88.9	1.8	—	5.2	6.5
94.4 94.4	4.8	2.4	50.0	9.3	2.4	9.6	9.6	10.2	6.7	2.0	74.5	74.5	—	—	—	2.0	3.3	5.3	—
83.8 97.1	4.0	2.9	72.5	8.5	2.6	9.7	8.8	9.0	5.5	1.6	74.0	44.5	4.4	4.0	90.9	1.6	3.3	5.0	6.4
89.2 88.9	4.5	2.2	48.7	8.4	2.1	9.8	9.6	9.6	6.1	1.9	70.0	37.0	4.7	3.9	82.9	1.8	2.6	5.3	6.1
96.9 94.1	4.1	2.1	51.2	7.5	2.0	8.0	7.9	8.5	5.6	1.6	75.0	65.0	4.0	3.5	87.5	1.5	3.0	4.5	5.4
91.9 97.3	4.5	1.8	40.0	8.2	2.0	9.1	9.0	9.4	6.9	2.4	70.5	60.0	4.4	3.8	86.4	2.4	2.7	5.2	6.1
105.9 105.9	4.6	2.3	50.0	8.6	2.6	9.3	9.0	9.3	6.2	1.7	70.0	61.0	4.3	4.0	93.0	1.8	2.9	5.0	6.1

Catalogue Number	Approximate Age Deformation.	Length	Breadth	Cephalic Index	Basi-Bregmatic Height	Height-Length Index	Height-Breadth Index	Capacity	Maximum Circumference	Nasion-Opisthion Arc	Thickness of Left Parietal	Nasion Prosthion	Maximum Bizygomatic Diameter	Upper Facial Index	Minimum Frontal Diameter	Breadth of Orbits (R. & L.)	Height of Orbits
♀ 15	35	17.2	12.8	74.4	13.0	75.6	101.6	1240	47.7	35.5	0.5	6.6	12.1	54.5	8.5	3.5 3.4	3.4 3.4
18	40sl.	17.4	13.8	79.3	12.8	73.6	92.7	1275	48.6	36.2	0.7	—	12.4	—	8.9	3.5 3.5	3.3 —
23	60	—	—	—	—	—	—	1310	—	36.0	0.7	—	12.9	—	9.1	3.7 3.7	3.7 3.6
25	40	—	—	—	—	—	—	1125	—	34.8	0.5	6.1	11.8	51.7	7.7	3.5 3.6	3.5 3.4
27	36	—	—	—	—	—	—	1115	—	34.8	0.8	—	—	—	7.9	3.5 3.4	3.4 3.4
32	24	16.8	13.6	81.0	12.7	75.6	93.4	1200	47.8	34.7	0.8	6.4	—	—	8.9	3.5 3.6	3.3 3.3
39	40	—	—	—	—	—	—	1190	—	35.6	0.8	6.1	12.4	49.2	8.2	3.5 3.5	3.5 3.5
42	50sl.	17.8	13.6	76.4	13.4	75.3	98.5	1390	50.1	38.1	0.8	6.5	12.2	53.3	9.0	3.4 3.4	3.4 3.3
43	38	17.2	13.0	75.6	12.8	74.4	98.5	1190	47.8	35.2	0.6	6.4	12.7	50.4	8.2	3.6 3.5	3.3 3.4
45	70sl.	—	—	—	—	—	—	1340	—	37.4	0.8	6.2	12.6	49.2	9.3	3.9 3.9	3.6 3.7
54	54	18.0	13.5	75.0	13.3	73.9	98.5	1410	50.3	37.5	0.8	6.3	12.4	50.8	9.4	3.6 3.7	3.1 3.2
56	24	16.8	13.0	77.4	12.6	75.0	96.9	1190	47.1	33.7	0.4	6.4	12.3	52.0	9.1	3.5 3.4	3.4 3.4
58	30	16.9	11.9	70.4	13.1	77.5	110.1	1140	46.7	35.3	0.7	6.2	11.7	52.9	8.8	3.4 3.4	3.3 3.3
61	48sl.	—	—	—	—	—	—	1170	—	34.5	0.4	6.5	—	—	8.6	— 3.7	4.1 4.1
62	60sl.	—	—	—	—	—	—	1205	—	34.0	0.4	6.7	12.0	55.8	8.5	3.7 3.7	3.4 3.4
64	50	17.7	13.2	74.6	13.6	76.8	103.0	1400	49.6	37.1	0.8	6.9	12.7	54.3	9.1	3.5 3.3	3.4 3.4
70	35sl.	16.6	12.8	77.1	13.0	78.3	101.6	1260	46.3	34.5	0.4	6.5	12.7	51.2	9.0	3.7 3.6	3.4 3.5
71	22sl.	16.6	12.6	75.9	12.7	76.5	100.8	1180	45.9	34.4	0.5	—	11.8	—	8.4	3.5 3.5	3.3 3.3
72	45	16.6	12.4	74.7	12.5	75.3	100.8	1090	45.7	33.8	0.7	5.9	—	—	8.4	3.5 3.5	3.2 3.3
73	50sl.	—	—	—	—	—	—	1130	—	34.0	0.4	6.2	12.1	51.2	8.0	3.5 3.4	3.3 3.4
77	22	15.9	12.4	78.0	12.2	76.7	98.4	1160	45.4	33.9	0.4	6.5	—	—	9.0	3.6 3.6	3.5 3.5
83	25sl.	—	12.6	—	—	—	—	1090	—	33.6	0.4	6.1	12.1	50.4	8.2	3.2 3.2	3.2 3.2
86	30sl.	—	—	—	—	—	—	1180	—	34.5	0.3	6.1	12.2	50.0	8.9	3.6 3.6	3.5 3.5
89	75sl.	17.3	13.5	78.0	13.9	80.3	102.9	1375	48.7	36.4	0.5	6.8	13.0	52.3	9.3	3.9 4.0	3.8 3.8
90	40sl.	—	—	—	—	—	—	1290	—	37.2	0.5	6.5	12.0	54.2	8.8	3.5 3.4	3.6 3.5
93	28	17.2	12.6	73.3	12.6	73.2	100.0	1215	47.7	35.1	0.5	5.8	12.2	47.5	8.6	3.5 3.5	3.5 3.5
95	30sl.	—	—	—	—	—	—	1335	—	37.1	0.4	6.7	12.4	54.0	8.9	3.8 3.7	3.5 3.5
104	38sl.	17.0	12.4	72.9	13.2	77.6	106.4	1280	47.1	36.5	0.4	6.2	12.3	50.4	9.2	3.7 3.6	3.3 3.3
105	26pr.	—	—	—	—	—	—	1190	—	36.3	0.6	6.3	12.4	50.8	8.2	3.7 3.6	3.6 3.5
109	40pr.	—	—	—	—	—	—	1285	—	37.5	0.5	6.5	12.4	52.4	8.7	3.4 3.4	3.5 3.5
110	50sl.	—	—	—	—	—	—	1055	—	33.5	0.4	5.9	11.8	50.0	8.2	3.3 3.3	3.3 3.2
111	55sl.	—	—	—	—	—	—	1150	—	34.8	0.4	5.9	12.0	47.5	8.4	3.3 3.2	3.3 3.3
113	36sl.	16.6	13.6	81.9	13.6	81.9	100.0	1310	47.3	35.8	0.4	6.0	12.4	48.4	9.1	3.6 3.6	3.5 3.5
114	24sl.	15.8	12.0	75.9	13.2	83.5	110.0	1060	44.2	33.7	0.5	5.5	—	—	8.1	3.3 —	3.2 —
128	40sl.	17.8	13.2	74.2	13.2	74.1	100.0	1250	48.7	36.2	0.6	5.8	—	—	9.4	3.6 3.5	3.2 3.2
130	55sl.	16.5	13.0	78.8	13.4	81.2	103.1	1200	46.2	34.2	0.3	6.5	—	—	8.5	3.6 3.6	3.5 3.5

Orbital Index	Length of Nose	Breadth of Nose	Nasal Index	Basion to Sub-nasal Point	Breadth between Orbits	Basion to Prosthion	Basion to Akanthion	Basion to Nasion	Prosthion to Nasion	Prosthion to Akanthion	Facial Angle	Alveolar Angle	Length of Palate	Breadth of Palate	Index of Palate	Prosthion to Sub-nasal Point	Mean Diameter of Foramen Magnum	Dental Arch Length	Dental Arch Breadth
97.1 100.0	4.8	2.3	47.9	8.2	2.3	8.8	8.5	9.1	6.6	1.9	71.0	64.5	4.2	4.0	95.2	1.8	2.9	4.9	5.5
94.3 —	4.6	2.6	56.5	8.4	2.4	—	9.2	93.	—	—	—	—	—	—	—	—	3.0	—	—
100.0 97.3	5.0	2.6	52.0	8.8	2.5	—	9.2	10.0	—	—	—	—	—	—	—	—	3.1	—	—
100.0 94.4	4.4	2.1	47.7	8.3	2.1	9.3	8.6	9.1	6.1	1.9	68.5	54.0	4.1	3.8	92.7	1.9	2.9	5.0	5.9
97.1 100.0	4.7	2.3	48.9	8.7	2.6	—	8.8	92.	—	—	—	—	4.0	3.4	85.0	1.6	2.9	—	—
94.3 91.7	4.5	2.1	46.7	8.2	2.3	8.8	8.7	9.1	6.4	1.8	71.5	64.5	4.4	3.7	84.1	1.8	2.8	5.1	6.1
100.0 100.0	4.7	2.4	51.1	8.8	2.3	9.5	9.2	9.7	6.1	1.6	73.5	61.5	4.4	4.1	93.2	1.6	3.0	5.7	6.3
100.0 97.1	4.9	2.2	44.9	8.2	2.5	9.1	8.7	9.2	6.5	1.8	69.0	53.0	4.7	—	—	1.7	2.9	4.9	—
91.7 97.1	4.6	2.5	54.3	8.5	2.1	9.5	9.0	9.4	6.4	2.0	69.0	54.0	4.5	3.7	82.2	1.9	3.0	5.2	6.3
92.3 94.9	4.7	2.2	46.8	8.8	2.3	9.6	9.6	9.8	6.2	1.6	73.0	56.5	4.3	—	—	1.6	3.0	5.1	—
86.1 86.5	4.2	2.2	52.4	8.4	2.3	9.4	9.0	9.4	6.3	2.3	70.0	56.5	4.2	4.2	100.0	2.1	2.7	5.2	6.5
97.1 100.0	4.4	2.0	45.4	8.2	2.4	9.8	8.8	9.2	6.4	2.0	71.5	63.0	4.2	4.0	95.2	1.9	3.2	4.8	6.0
97.1 97.1	4.5	2.4	53.3	8.9	2.3	9.3	9.1	9.4	6.2	1.9	72.0	72.0	4.3	4.0	93.0	1.7	3.0	4.8	6.1
— 110.8	4.0	2.4	60.0	8.3	2.3	9.0	8.9	9.4	6.5	2.0	72.5	63.0	4.1	—	—	1.9	3.1	5.0	—
91.9 91.9	4.7	2.7	57.4	8.4	2.2	9.2	9.0	9.2	6.7	2.1	68.5	61.0	4.5	—	—	2.0	3.2	4.6	—
97.1 103.0	4.8	2.3	47.9	8.5	2.3	9.4	8.8	9.4	6.9	2.2	68.5	59.0	4.3	4.1	95.3	2.1	3.2	5.0	6.4
91.9 97.2	4.7	2.5	53.2	8.4	2.1	9.6	9.0	9.3	6.5	1.7	67.5	43.0	—	3.7	—	1.7	3.3	5.3	5.8
94.3 94.3	—	—	—	—	2.1	—	—	9.3	—	—	—	—	—	3.3	—	—	2.9	—	5.7
91.4 94.3	4.1	2.4	58.5	8.4	2.0	9.2	9.0	9.0	5.9	1.9	69.0	59.0	4.6	—	—	1.8	3.4	4.9	6.0
94.3 100.0	6.2	1.9	30.6	8.0	1.9	8.9	8.6	8.8	6.2	1.7	68.5	53.0	4.2	—	—	1.7	3.2	4.7	—
97.2 97.2	4.6	2.4	52.2	7.7	2.1	8.6	8.2	8.4	6.5	2.1	66.0	56.5	4.2	3.7	88.1	2.0	3.2	5.0	6.1
100.0 100.0	4.4	2.3	52.3	8.4	2.1	9.3	9.0	8.8	6.1	1.8	66.0	57.0	4.6	3.3	71.7	1.9	2.8	5.1	5.9
97.2 97.2	4.7	2.4	51.1	8.3	2.1	9.3	8.9	9.3	6.1	2.0	70.0	53.0	4.4	4.0	90.9	1.8	3.2	5.0	6.1
97.4 95.0	5.2	2.2	42.3	8.1	2.1	9.0	8.9	9.5	6.8	1.8	72.5	56.0	4.4	—	—	1.8	3.2	5.0	—
102.8 102.9	4.6	2.4	52.2	8.8	2.4	9.8	9.0	9.2	6.5	2.0	65.5	54.0	4.3	4.2	9.77	2.0	2.8	5.2	6.3
100.0 100.0	4.3	2.1	48.8	8.6	2.3	9.3	9.2	9.6	5.8	1.6	75.0	60.5	4.3	3.7	86.0	1.6	3.0	5.0	5.9
92.1 94.6	4.4	2.3	52.3	8.6	2.3	9.6	9.1	9.3	6.7	2.4	66.5	56.5	4.6	4.1	89.1	2.2	3.2	5.3	6.6
89.2 91.7	4.6	2.6	56.5	8.2	2.2	9.0	8.6	9.2	6.2	1.7	71.5	57.5	4.4	3.7	84.1	1.7	3.0	5.0	6.0
97.3 97.2	4.7	2.5	53.2	8.4	2.2	9.2	8.8	9.1	6.3	1.7	69.0	58.0	4.3	3.9	90.7	1.7	3.3	5.0	6.0
102.9 102.9	4.5	2.1	46.9	8.8	2.4	9.6	9.3	9.5	6.5	2.0	69.0	61.0	4.4	—	—	2.0	2.7	5.1	5.9
100.0 96.9	4.2	2.4	57.1	8.2	2.1	9.0	8.6	8.8	5.9	1.7	68.5	58.0	3.9	—	—	1.7	2.6	4.6	—
100.0 103.1	4.5	2.4	53.3	8.3	2.2	9.1	8.6	9.2	5.9	1.6	72.0	56.0	4.3	—	—	1.6	2.8	4.9	—
97.2 97.2	4.4	2.6	59.1	8.0	2.4	9.0	8.6	9.2	6.0	1.8	72.0	51.0	4.1	4.2	102.4	1.7	3.3	5.1	6.4
96.9 —	4.1	—	—	8.3	2.3	9.0	8.5	9.3	5.5	1.6	75.0	60.0	4.1	3.7	90.2	1.6	2.8	4.4	5.9
88.9 91.4	4.5	2.3	51.1	8.7	2.5	9.4	9.1	9.8	5.8	1.5	76.0	60.0	4.5	3.8	84.4	1.5	3.1	5.0	6.3
97.2 97.2	4.8	2.4	50.0	8.0	1.9	8.4	8.6	9.6	6.5	1.9	79.0	70.0	3.9	3.8	97.4	1.9	2.9	4.7	5.6

Catalogue Number	Approximate Age Deformation.	Length	Breadth	Cephalic Index	Basi-Bregmatic Height	Height-Length Index	Height-Breadth Index	Capacity	Maximum Circumference	Nasion-Opisthion Arc	Thickness of Left Parietal	Nasion Prosthion	Maximum Bizygomatic Diameter	Upper Facial Index	Minimum Frontal Diameter	Breadth of Orbits (R. & L.)	Height of Orbits
♀ 133	40pr.	—	—	—	—	—	—	1352	—	—	0.4	6.3	12.0	52.5	8.3	3.6 3.5	3.6 3.5
137	30sl.	16.0	12.4	77.5	11.5	71.9	92.7	1020	45.4	32.7	0.4	6.0	11.9	50.4	8.1	3.3 3.3	3.3 3.3
138	28sl.	—	—	—	—	—	—	1090	—	35.3	0.6	6.0	—	—	8.2	— 3.4	— 3.5
139	40	17.0	13.2	77.6	13.3	78.2	100.7	1320	48.1	34.4	0.4	—	—	—	8.9	3.7 3.7	3.7 3.7
153	25sl.	—	—	—	—	—	—	1130	—	34.3	0.4	6.4	12.5	51.2	8.8	3.6 3.6	3.2 3.3
159	22	18.0	13.4	74.4	12.8	71.1	95.5	1320	49.0	36.9	0.4	7.1	12.6	56.3	9.2	3.6 3.6	3.5 3.4
165	28pr.	—	—	—	—	—	—	1385	—	36.9	0.4	6.7	12.7	52.8	8.8	3.5 3.5	3.6 3.6
190	24sl.	—	—	—	—	—	—	1345	—	37.3	0.5	6.0	12.5	48.0	9.5	3.4 3.3	3.4 3.4
924	50sl.	—	—	—	—	—	—	1125	—	34.7	0.4	6.4	12.8	50.0	9.0	3.4 3.5	3.5 3.5
♂♀ 5	40	17.4	13.8	79.3	12.8	73.6	92.7	1290	47.8	35.8	0.6	—	—	—	8.4	— —	— —
7	20	17.8	13.1	73.6	14.4	80.9	109.9	1470	48.4	37.4	0.5	7.1	12.2	58.2	8.8	3.5 3.5	3.5 3.5
121	22	17.1	12.8	74.9	12.8	74.8	100.0	1240	47.0	34.4	0.4	6.5	—	—	8.5	3.4 3.4	3.4 3.5
149	50	—	—	—	—	—	—	1250	— —	35.8	0.4	6.8	12.6	53.9	9.0	3.6 3.6	3.3 3.3
PATALLACTA																	
♂628	65	18.5	13.8	74.6	14.8	80.0	107.2	—	51.5	38.8	0.4	7.2	13.6	52.9	10.1	3.8 3.8	3.4 3.5
629	24	17.9	13.8	77.1	14.8	82.1	107.2	1570	50.1	37.6	0.3	7.0	13.3	52.6	9.3	3.6 3.7	3.5 3.5
631	80sl.	17.5	13.8	78.9	13.5	77.1	90.6	1445	48.7	36.0	0.4	6.3	—	—	9.2	3.7 3.6	3.6 3.6
633	50	17.8	13.7	77.0	14.0	78.6	102.2	1465	49.4	36.8	0.4	7.1	—	—	9.0	3.7 3.7	3.5 3.6
634	55sl.	—	—	—	—	—	—	1540	—	38.0	0.4	7.0	13.0	53.8	9.7	3.8 3.7	3.6 3.5
635	26	17.6	14.0	79.5	13.5	76.7	96.4	1400	49.3	35.5	0.4	6.8	13.7	49.6	8.5	3.4 3.4	3.3 3.3
637	20	17.7	14.0	79.1	13.7	77.4	97.8	1450	50.4	35.7	0.4	6.9	13.6	50.7	9.2	3.7 3.8	3.4 3.4
638	48	17.6	13.8	78.4	13.5	76.7	90.6	1272	48.6	33.9	0.4	7.2	12.2	59.5	9.0	3.7 3.7	3.6 3.6
639	60sl.	—	—	—	—	—	—	1395	—	37.9	0.4	7.7	14.3	53.8	9.3	3.9 3.8	3.7 3.8
640	55	17.6	13.7	77.8	14.4	81.8	105.1	1425	49.3	36.4	0.3	7.2	13.5	53.5	9.0	3.6 3.6	3.4 3.4
643	55sl.	—	—	—	—	—	—	1350	—	36.4	0.6	6.9	—	—	9.9	3.6 3.6	3.7 3.6
645	65	19.0	13.6	71.6	14.9	78.4	109.5	1525	51.6	38.6	0.4	7.5	14.5	51.7	9.7	3.8 3.8	3.6 3.7
646	75	18.5	14.0	75.7	14.2	76.7	101.4	1565	51.2	38.5	0.4	6.8	—	—	9.0	3.9 3.8	3.4 3.5
647	70sl.	17.2	13.3	77.3	13.4	77.9	100.7	1320	47.6	35.4	0.4	—	13.4	—	8.6	3.5 —	3.5 —
653	65pr.	—	—	—	—	—	—	1415	—	38.3	0.4	7.4	—	—	8.8	3.7 3.6	3.6 3.6
654	70	18.8	14.4	76.6	14.2	75.5	98.6	1570	52.0	38.0	0.6	6.9	14.0	49.3	9.0	4.0 3.9	3.6 3.6
655	65	17.5	14.2	81.1	12.7	72.6	89.4	1330	49.3	37.6	0.4	6.2	—	—	9.3	3.7 —	3.5 3.5
663	30sl.	17.4	13.9	79.9	13.6	78.2	97.8	1485	49.4	37.3	0.4	6.7	14.2	47.2	9.2	3.4 3.4	3.3 3.1
930	65	18.7	14.2	75.9	13.7	73.3	96.5	1542	52.4	38.3	0.5	6.8	14.0	48.6	10.4	3.7 3.7	3.6 3.6
932	24	17.6	13.4	76.1	13.5	76.7	100.7	1320	49.1	35.3	0.4	7.2	13.7	52.5	9.3	3.7 3.6	3.5 3.5

Orbital Index	Length of Nose	Breadth of Nose	Nasal Index	Basion to Sub-nasal Point	Breadth between Orbits	Basion to Prosthion	Basion to Akanthion	Basion to Nasion	Prosthion to Nasion	Prosthion to Akanthion	Facial Angle	Alveolar Angle	Length of Palate	Breadth of Palate	Index of Palate	Prosthion to Sub-nasal Point	Mean Diameter of Foramen Magnum	Dental Arch Length	Dental Arch Breadth
100.0 100.0	4.7	2.1	44.7	8.3	1.9	9.1	8.9	9.4	6.3	1.8	72.5	59.0	4.2	3.7	88.1	1.8	2.8	5.0	5.7
100.0 100.0	4.1	2.0	48.8	7.9	1.9	8.5	8.2	8.6	6.0	1.8	70.0	65.0	4.3	3.3	79.1	1.8	2.8	4.6	5.3
—— 102.9	4.1	2.2	53.7	8.2	2.0	8.8	8.6	9.3	6.0	2.0	75.0	65.5	4.0	3.4	85.0	1.9	2.8	4.8	5.7'
100.0 100.0	4.8	2.4	50.0	8.6	1.9	—	8.9	9.8	—	—	—	—	—	—	—	—	3.5	—	—
88.9 91.7	4.7	2.6	55.3	8.5	2.6	9.2	9.1	9.5	6.4	1.8	72.5	62.5	4.4	3.6	81.8	1.8	3.0	5.0	5.8
97.2 94.4	4.9	2.4	48.9	8.3	2.1	9.6	8.5	9.5	7.1	2.4	67.5	51.0	4.8	3.9	81.2	2.3	2.9	5.1	6.5
102.8 102.8	4.7	2.3	48.9	8.6	2.3	9.8	9.0	9.6	6.7	2.3	68.0	53.0	4.9	4.0	81.6	2.3	3.5	5.2	6.2
100.0 103.0	3.9	2.4	61.5	9.1	2.7	9.9	9.6	9.9	6.0	2.4	72.5	63.5	4.6	3.9	84.8	2.2	3.3	5.5	6.6
102.9 100.0	4.6	2.5	54.3	8.3	2.6	9.0	8.9	9.4	6.4	1.9	73.0	63.5	4.5	3.6	80.0	1.8	2.9	4.9	5.3'
—— ——	—	—	—	—	2.4	—	—	9.0	—	—	—	—	—	4.2	—	—	3.0	5.1	6.2
100.0 100.0	5.0	2.4	48.0	8.6	2.4	9.7	9.4	10.0	7.1	2.4	71.0	53.0	4.5	4.0	88.9	2.1	3.5	5.3	6.4
100.0 102.9	4.7	2.1	44.7	8.5	2.3	9.2	9.1	9.5	6.5	1.6	72.0	58.0	4.0	3.3	82.5	1.6	3.2	4.9	5.8
91.7 91.7	4.7	2.6	55.3	9.6	2.3	10.5	10.1	9.8	6.8	2.1	65.0	59.0	4.9	4.0	81.6	2.0	3.1	5.4	6.2
89.5 92.1	4.9	2.4	48.9	8.8	2.8	10.0	9.5	10.4	7.2	2.4	72.0	55.0	5.1	3.9	76.5	2.4	3.4	5.5	6.3
97.2 94.6	5.3	2.4	45.3	8.7	2.0	9.8	9.4	10.3	7.0	2.0	73.0	52.0	4.7	4.1	87.2	1.9	3.5	5.4	6.9
97.3 100.0	4.6	2.5	54.3	8.6	2.5	9.4	9.3	9.6	6.3	1.9	72.5	60.0	4.5	—	—	1.7	3.5	5.0	—
94.6 97.3	5.0	2.5	50.0	8.9	2.3	9.6	9.6	10.0	7.1	2.3	72.0	65.0	4.0	4.1	102.5	2.1	3.4	4.7	6.5
94.7 94.6	4.9	2.4	48.9	8.4	2.7	9.1	8.9	10.2	7.0	2.4	77.0	64.0	4.3	3.7	86.0	2.2	3.0	4.5	6.0
97.1 97.1	4.7	2.2	46.8	8.5	2.1	9.2	9.4	9.8	6.8	2.3	73.5	64.5	4.5	4.1	91.1	2.2	3.7	5.1	6.5
91.9 89.5	4.7	2.4	51.1	9.0	2.4	10.0	9.9	10.2	6.9	2.2	71.5	58.5	4.7	4.0	85.1	2.2	3.5	5.5	6.8'
79.3 97.3	4.9	2.3	46.9	9.4	2.3	10.2	10.4	10.7	7.2	2.2	73.5	63.5	4.6	3.8	82.6	2.4	3.1	5.2	6.3
94.9 100.0	5.4	2.5	46.3	9.6	2.5	10.5	10.2	10.6	7.7	2.4	69.0	61.0	4.9	3.9	79.6	2.3	3.4	5.8	6.5
94.4 94.4	5.3	2.4	45.3	8.5	2.4	9.6	9.2	10.4	7.2	2.0	75.0	53.5	4.7	3.9	82.9	2.1	3.3	5.1	6.5
102.8 100.0	5.1	2.5	49.0	9.0	3.1	9.8	9.3	10.3	6.9	2.1	74.0	61.0	4.5	—	—	2.3	3.2	5.0	—
94.7 97.4	5.3	2.8	52.8	9.4	2.7	10.4	10.2	11.0	7.5	2.2	73.5	57.0	5.1	4.6	90.2	2.1	3.7	5.8	7.0
87.2 92.1	4.8	2.2	45.8	8.1	2.2	9.1	8.8	10.0	6.8	2.2	76.0	56.0	4.2	—	—	2.1	3.2	—	—
100.0 ——	5.1	2.4	47.1	9.0	2.3	—	9.6	9.9	—	—	—	—	—	—	—	—	3.4	—	—
97.3 100.0	5.0	2.4	48.0	8.6	2.4	9.7	9.2	9.7	7.4	2.4	68.0	56.0	4.7	3.9	82.9	2.3	3.3	5.1	6.2
90.0 92.3	5.2	2.4	46.1	9.0	2.2	9.9	9.3	10.5	6.9	2.3	74.5	60.0	—	—	—	2.2	3.6	—	—
94.6 ——	4.8	2.3	47.9	8.2	2.6	9.0	8.9	9.3	6.2	1.7	72.5	57.5	—	—	—	1.6	2.9	—	—
97.1 91.2	4.7	2.7	57.4	8.8	2.6	10.0	9.4	9.6	6.7	2.3	67.0	53.5	4.9	4.0	81.6	2.3	3.4	5.5	6.7'
97.3 97.3	5.3	2.7	50.9	8.4	3.4	8.9	9.0	10.0	6.8	2.1	—	—	4.6	—	—	—	3.6	5.1	6.1
94.6 97.2	5.2	2.2	42.3	8.4	2.3	9.4	9.0	10.0	7.2	2.1	—	—	4.7	3.7	78.7	—	3.2	5.4	5.8

Catalogue Number	Approximate Age Deformation.	Length	Breadth	Cephalic Index	Basi-Bregmatic Height	Height-Length Index	Height-Breadth Index	Capacity	Maximum Circumference	Nasion-Opisthion Arc	Thickness of Left Parietal	Nasion Prosthion	Minimum Bizygomatic Diameter	Upper Facial Index	Minimum Frontal Diameter	Breadth of Orbits (R. & L.)	Height of Orbits
♂934	30sl.	16.4	13.1	79.9	13.3	81.1	101.5	1190	46.5	——	0.6	7.0	12.5	56.0	8.7	3.7 3.6	3.8 3.8
937	20	18.2	14.2	78.0	13.0	71.4	91.5	1430	51.6	37.3	0.5	6.3	13.0	48.5	9.5	3.3 3.4	3.4 3.3
956	50sl.	17.0	12.9	75.9	13.3	78.2	103.1	1235	47.0	35.7	0.4	6.6	13.3	49.6	9.1	3.8 3.7	2.9 3.1
962	23	16.5	12.7	77.0	12.7	76.9	100.0	1155	46.8	33.9	0.4	6.2	——	——	9.0	3.7 3.7	3.4 3.4
968	65	18.8	14.0	74.5	14.6	77.7	104.3	1430	52.7	37.3	0.6	7.0	14.6	47.9	10.1	4.1 4.0	3.5 3.6
♀630	55	16.7	13.0	77.8	12.7	76.0	97.7	1065	46.6	34.4	0.5	6.9	——	——	8.5	3.4 3.3	3.3 3.3
632	28	17.5	13.8	78.9	14.2	81.1	102.2	1450	48.9	37.2	0.4	6.8	12.7	53.5	8.9	3.7 3.7	3.3 3.3
636	30pr.	——	——	——	——	——	——	1230	——	36.9	0.4	6.9	12.6	54.8	9.0	3.3 3.3	3.8 3.8
641	50	16.7	12.7	76.0	13.0	77.8	102.4	1200	47.7	34.6	0.4	——	——	——	9.1	3.5 3.5	3.4 3.5
657	25	17.8	13.2	74.2	13.2	74.1	100.0	1285	49.4	36.1	0.5	6.3	12.5	50.4	9.0	3.5 3.4	3.2 3.2
660	65sl.	17.4	12.3	70.7	13.0	74.7	105.7	1205	47.3	36.0	0.5	——	12.7	——	9.3	3.4 3.4	3.5 3.5
664	35	16.7	13.4	80.2	13.2	77.9	98.5	1190	48.4	34.6	0.4	6.2	12.6	49.2	8.4	3.6 3.7	3.4 3.4
746	60	17.0	12.1	71.2	13.2	77.6	109.1	1140	46.4	34.9	0.4	6.2	12.1	51.2	8.7	3.5 3.5	3.2 3.2
931	30	17.0	13.2	77.6	12.0	70.6	90.9	1172	47.7	34.7	0.4	6.3	12.2	51.6	8.8	3.4 3.4	3.6 3.6
933	30sl.	16.8	13.2	78.6	12.5	74.4	94.7	1225	48.3	34.5	0.4	6.3	12.4	50.8	9.5	3.5 3.5	3.4 3.4
935	40sl.	17.2	13.3	77.3	13.0	75.6	97.7	1260	48.4	35.2	0.6	6.3	——	——	9.3	—— 3.6	—— 3.5
936	40	16.7	13.0	77.8	13.3	79.6	102.3	——	——	34.5	0.6	——	——	——	8.2	3.6 ——	3.4 ——
949	22	16.4	13.0	79.3	12.8	78.0	98.5	1185	47.0	34.4	0.4	——	——	——	8.5	—— ——	—— ——
958	60sl.	16.8	12.2	72.6	13.2	78.6	100.8	1105	45.6	35.7	0.6	——	12.3	——	8.3	3.6 3.6	3.5 3.5
959	28	16.2	13.0	80.2	11.7	72.2	90.0	1085	46.4	32.7	0.4	——	12.2	——	8.8	3.5 3.3	3.1 3.2
960	26sl.	16.6	12.8	77.1	13.0	78.3	101.6	1190	47.7	33.9	0.4	6.4	12.4	51.6	9.0	3.5 3.5	3.5 3.6
961	28sl.	16.8	12.0	71.4	13.0	77.4	108.3	1062	46.7	34.9	0.4	——	——	——	8.0	—— ——	—— ——
964	22	17.4	13.9	79.9	13.6	78.2	97.8	1398	48.2	36.2	0.4	6.2	11.8	52.5	9.1	—— 3.3	3.2 3.2
969	60	16.4	13.6	82.9	13.4	81.7	98.5	1285	48.4	35.6	0.4	——	12.5	——	9.2	3.8 3.7	3.2 3.2
HUATA																	
♂877	55	18.1	14.0	77.3	13.5	74.6	96.4	1456	51.0	38.4	0.6	6.9	13.1	52.7	9.3	3.7 3.7	3.3 3.4
878	35sl.	17.1	13.4	78.4	13.9	81.3	103.7	1350	47.8	35.7	0.4	6.7	13.9	48.2	9.3	3.7 3.8	3.7 3.6
880	24	18.4	14.4	78.3	14.4	78.2	100.0	1670	51.4	38.5	0.4	7.0	13.9	50.4	9.6	3.7 3.7	3.5 3.6
881	28	17.7	14.4	81.4	13.9	78.5	96.5	1550	51.0	3.81	0.4	6.7	13.8	48.5	9.8	3.6 3.5	3.3 3.3
882	50	17.6	13.2	75.0	13.7	77.8	103.8	1416	49.5	35.8	0.4	6.3	14.2	44.4	9.2	3.7 3.7	3.4 3.4
884	65sl.	——	——	——	——	——	——	1505	——	38.4	0.4	——	13.5	——	8.8	3.7 3.6	3.6 3.6
886	50pr.	——	——	——	——	——	——	1452	——	38.3	0.4	7.7	——	——	8.9	3.6 3.6	3.5 3.5
887	50sl.	——	——	——	——	——	——	1360	——	37.3	0.4	——	13.6	——	8.9	3.7 3.5	3.5 ——
♀883	60	16.6	12.8	77.1	12.9	77.7	100.8	1140	47.0	35.0	0.4	6.0	12.6	47.6	8.8	3.4 3.3	3.1 3.1
888	28	16.9	13.0	76.9	12.4	73.4	95.4	1150	48.3	35.4	0.5	6.3	12.8	49.2	9.2	3.5 3.5	3.0 3.0
889	50sl.	——	——	——	——	——	——	1235	——	36.1	0.5	7.0	——	——	8.6	3.4 3.5	—— 3.4

Orbital Index	Length of Nose	Breadth of Nose	Nasal Index	Basion to Sub-nasal Point	Breadth between Orbits	Basion to Prosthion	Basion to Akanthion	Basion to Nasion	Prosthion to Nasion	Prosthion to Akanthion	Facial Angle	Alveolar Angle	Length of Palate	Breadth of Palate	Index of Palate	Prosthion to Sub-nasal Point	Mean Diameter of Foramen Magnum	Dental Arch Length	Dental Arch Breadth
102.7 105.5	5.0	2.2	44.0	8.1	2.1	8.9	8.3	9.3	7.0	2.1	72.0	61.0	4.3	3.6	83.7	2.0	—	4.9	6.0
103.0 97.1	4.8	2.7	56.2	8.7	2.7	9.3	9.1	9.4	6.3	1.6	71.0	58.0	4.4	4.2	95.4	1.4	3.6	5.2	6.9
73.7 83.8	4.3	2.4	55.8	8.7	2.3	9.4	9.2	9.6	6.6	1.9	71.0	59.0	4.6	3.8	82.6	1.7	3.0	5.3	6.3
91.9 91.9	4.6	2.4	52.2	8.4	2.4	8.9	9.0	9.3	6.2	1.9	73.0	66.0	4.1	3.8	92.7	1.7	3.0	4.8	6.0
85.4 90.0	5.1	2.8	54.9	9.8	2.6	10.6	10.1	10.6	7.0	2.0	71.0	65.0	4.9	4.3	87.7	2.1	3.3	5.9	6.8
97.1 100.0	4.9	2.2	44.9	8.0	2.1	8.7	8.7	9.0	6.9	2.3	69.0	64.0	4.1	3.5	85.4	2.2	2.7	5.1	5.8
89.2 89.2	4.7	2.2	46.8	8.2	2.1	8.8	8.9	10.0	6.8	2.1	78.0	67.0	4.4	3.7	84.1	2.1	3.0	5.0	5.9'
115.1 115.1	5.2	2.4	46.1	8.5	2.6	9.4	9.1	9.6	6.9	1.8	70.0	55.0	4.4	4.1	93.2	1.8	3.1	5.1	6.3
97.1 100.0	4.8	2.3	47.9	8.2	2.4	—	8.5	9.6	—	—	—	—	—	—	—	—	2.9	—	—
91.4 94.1	4.9	2.5	51.0	9.0	2.3	9.6	9.6	10.1	6.3	1.6	75.5	63.5	4.4	3.9	88.6	1.5	3.2	5.0	6.1
94.4 91.9	4.6	2.5	55.3	8.4	2.1	9.0	8.9	9.4	6.2	1.7	73.4	65.0	4.3	—	—	1.7	3.0	—	—
91.4 91.4	4.5	2.5	55.5	8.8	2.3	9.8	9.2	9.6	6.2	1.7	69.5	52.0	4.7	3.6	76.6	1.7	2.9	5.4	5.8
102.9 102.9	5.0	2.7	54.0	8.5	3.0	—	8.8	9.4	—	—	—	—	—	—	—	—	3.1	—	—
105.9 105.9	4.9	2.3	46.9	7.8	2.1	8.5	82.	9.0	6.3	1.6	73.0	57.0	4.0	3.6	90.0	1.4	3.1	4.5	5.5
97.1 97.1	4.6	2.5	54.3	8.8	2.3	9.6	9.3	9.4	6.3	1.9	69.0	59.0	4.6	4.3	93.5	1.9	3.3	5.1	6.6
— 97.2	4.8	—	—	8.1	2.5	8.8	8.5	9.5	6.3	1.6	76.0	57.0	—	—	—	1.5	3.2	—	—
94.4 —	4.7	—	—	8.4	2.0	—	8.6	9.7	—	—	—	—	—	—	—	—	—	—	—
— —	—	—	—	—	—	—	—	9.4	—	—	—	—	—	—	—	—	2.8	—	—
97.2 97.2	4.6	2.5	54.3	8.4	2.0	—	8.8	9.3	—	—	—	—	—	—	—	—	3.1	—	—
88.6 96.9	4.2	2.5	59.5	8.5	2.3	—	—	9.0	—	—	—	—	—	—	—	—	2.7	—	—
100.0 102.8	4.7	2.1	44.7	8.4	2.3	9.4	8.9	9.4	6.4	2.1	70.0	53.0	4.5	3.7	82.2	1.9	3.1	4.9	5.9
— —	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2.8	—	—
— 96.9	4.3	2.3	53.5	8.5	2.5	9.6	9.2	9.5	6.2	2.0	70.0	53.0	4.4	3.6	81.8	2.1	3.3	5.1	6.0
84.2 86.3	5.0	2.3	46.0	8.1	2.0	—	8.5	9.4	—	—	—	—	—	—	—	—	2.9	—	—
89.2 91.9	4.7	2.6	55.3	9.2	2.1	10.2	10.0	9.4	6.9	2.3	63.0	57.0	4.9	4.2	85.7	2.2	3.4	5.7	6.6
100.0 94.7	4.8	2.6	54.2	9.2	2.5	10.1	10.0	10.1	6.7	2.2	70.0	60.5	4.8	4.3	89.6	2.2	3.1	5.5	6.5
94.6 97.3	5.0	2.6	52.0	8.7	2.7	9.6	9.2	10.1	7.0	2.2	72.5	59.0	4.4	4.2	95.4	2.1	3.6	5.3	6.9
91.7 94.3	5.0	2.4	48.0	8.4	2.7	9.2	9.0	9.8	6.7	2.1	73.5	59.0	4.3	4.1	95.3	1.9	3.3	5.3	6.6
91.9 91.9	4.6	2.6	56.5	9.2	2.7	10.0	10.0	10.2	6.3	1.9	73.5	59.5	5.1	4.1	80.4	1.8	3.7	5.6	6.3
97.3 100.0	5.1	2.5	49.0	8.8	2.1	—	9.4	10.0	—	—	—	—	—	—	—	—	3.2	—	—
97.2 97.2	5.4	2.1	38.9	8.4	2.2	9.6	9.3	9.5	7.7	2.2	65.0	51.5	4.5	3.8	84.4	2.2	3.2	5.4	6.4
94.6 —	5.1	2.2	43.1	9.0	2.0	—	9.6	10.1	—	—	—	—	4.3	—	—	—	3.2	—	—
91.2 93.9	4.2	2.5	59.5	8.2	2.2	9.3	9.0	9.2	6.0	1.8	70.0	50.0	4.6	—	—	1.8	—	—	—
85.7 85.7	4.5	2.7	60.0	8.4	2.1	9.3	9.0	9.0	6.3	1.9	67.0	57.0	4.8	3.7	77.1	1.9	2.9	5.4	6.3
— 97.1	5.0	2.5	50.0	8.5	2.6	9.1	8.8	10.0	7.0	2.2	75.0	66.0	4.5	—	—	2.1	2.9	—	—

Catalogue Number	Approximate Age Deformation.	Length	Breadth	Cephalic Index	Basi-Bregmatic Height	Height-Length Index	Height-Breadth Index	Capacity	Minimum Circumference	Nasion-Opisthion Arc	Thickness of Left Parietal	Nasion Prosthion	Maximum Bizygomatic Diameter	Upper Facial Index	Minimum Frontal Diameter	Breadth of Orbits (R. & L.)	Height of Orbits
YANAMANCHI																	
♂911	25	17.4	13.8	79.3	13.8	79.3	100.0	1350	49.0	35.1	0.4	6.2	13.3	46.6	8.9	3.5 3.4	3.2 3.2
912	30pr.	—	—	—	—	—	—	1245	—	37.0	0.4	7.2	13.0	55.4	8.2	3.6 3.6	3.6 3.7
♀913	23	16.8	13.5	80.4	12.2	73.2	90.4	1165	47.6	34.0	0.3	—	—	—	8.7	3.4 3.4	3.2 3.1
SILLQUE																	
♂915	45	17.4	13.6	78.2	12.8	73.6	94.1	1240	48.3	35.7	0.4	6.6	14.1	46.8	9.5	3.7 3.7	3.5 3.5
HUISPANG																	
♂921	25	17.8	12.6	70.8	12.8	71.9	101.6	1160	48.5	35.4	0.4	6.8	13.2	51.5	9.0	3.8 3.8	3.4 3.4
HUAROCONDO																	
♂923	45	18.4	13.7	74.5	13.6	73.9	99.3	1470	51.0	36.8	0.6	7.1	13.7	51.8	9.8	4.0 4.0	3.5 3.5
TORONTOY																	
♂747	65	18.0	14.1	78.3	13.4	74.4	95.0	1400	50.3	37.1	0.4	7.5	14.3	52.4	9.0	3.7 3.6	3.8 3.7
748	60	18.0	12.9	71.7	13.6	75.5	105.4	1395	49.7	37.0	0.4	6.8	12.8	53.1	8.8	3.8 3.5	3.7 3.6
749	65	18.0	13.2	73.3	13.4	74.4	101.5	1325	49.5	37.0	0.4	6.3	12.8	49.2	9.0	3.6 3.7	3.4 3.4
752	40	18.6	13.6	73.1	13.2	70.9	97.0	1380	49.9	36.6	0.4	6.8	14.2	47.9	9.4	4.0 4.0	3.5 3.5
757	30	18.6	14.0	75.3	13.3	71.5	95.0	1390	51.0	37.6	0.4	7.0	13.3	52.6	9.2	3.6 3.4	3.2 3.2
758	28	17.8	13.1	73.6	13.3	74.7	101.5	1420	49.3	37.1	0.3	6.7	13.3	50.4	8.9	3.9 3.7	3.5 3.5
760	38pr.	—	—	—	—	—	—	1210	—	36.3	0.4	7.3	—	—	8.5	3.5 3.5	3.7 3.7
761	65	17.6	13.2	75.0	13.5	76.7	102.3	1280	48.9	36.0	0.4	6.9	—	—	9.2	3.8 3.8	3.3 3.3
770	40	17.6	13.5	76.7	14.1	80.1	104.4	1390	48.6	36.3	0.5	7.0	13.3	52.6	9.1	3.7 3.6	3.6 3.6
790	30	18.1	13.2	72.9	14.2	78.4	107.6	1390	49.6	35.8	0.4	6.8	13.7	49.6	9.3	3.7 3.7	3.3 3.4
791	55	18.2	13.7	75.3	13.4	73.6	97.8	1355	49.8	35.4	0.5	7.3	13.9	52.5	9.2	3.9 3.7	— 3.7
♀750	28	16.8	13.0	77.4	12.9	70.8	99.2	1180	46.3	34.2	0.4	6.0	11.7	51.3	8.0	3.3 3.4	3.3 3.4
751	35sl.	18.0	—	—	12.6	70.0	—	1290	48.6	36.0	0.4	6.8	—	—	9.4	3.7 3.7	3.7 3.7
759	55	17.3	13.2	76.3	12.6	72.8	95.4	1200	48.0	35.1	0.4	6.4	—	—	9.2	— 3.7	— 3.6
767	40sl.	17.4	12.2	70.1	12.2	70.1	100.0	1240	47.8	35.5	0.4	6.6	12.4	53.2	8.6	3.6 3.5	3.3 3.4
768	42	17.2	13.3	77.3	12.7	73.8	95.5	1180	47.7	35.9	0.5	6.2	12.2	50.8	8.2	3.4 3.4	3.5 3.6
769	40	17.8	12.4	69.7	12.3	69.1	99.2	1305	48.6	36.9	0.4	6.3	12.3	51.2	8.8	3.5 3.5	3.4 3.4
777	50sl.	—	—	—	—	—	—	1060	—	34.2	0.4	6.3	12.1	52.1	8.4	3.4 3.4	3.4 3.4
782	55sl.	17.1	13.2	77.2	13.7	80.1	103.8	1335	48.3	35.9	0.4	6.4	12.8	50.0	8.8	3.8 3.7	3.4 3.4
786	21	16.3	12.7	77.9	12.6	77.3	99.2	1140	46.0	34.3	0.4	5.9	11.5	51.3	8.2	3.4 3.3	3.4 3.4

Orbital Index	Length of Nose	Breadth of Nose	Nasal Index	Basion to Sub-nasal Point	Breadth between Orbits	Basion to Prosthion	Basion to Akanthion	Basion to Nasion	Prosthion to Nasion	Prosthion to Akanthion	Facial Angle	Alveolar Angle	Length of Palate	Breadth of Palate	Index of Palate	Prosthion to Sub-nasal Point	Mean Diameter of Foramen Magnum	Dental Arch Length	Dental Arch Breadth
91.4 94.1	4.5	2.4	53.3	8.6	2.2	9.4	9.1	9.4	6.2	2.2	70.5	61.0	—	4.0	—	2.0	3.2	5.1	64.
100.0 102.8	4.7	2.7	57.4	9.2	2.4	10.3	9.8	10.2	7.2	2.6	68.5	57.0	4.8	4'2	87.5	2.5	3.1	5.3	6.5
94.1 91.2	4.5	2.5	55.5	—	2.2	—	—	—	—	—	—	—	—	—	—	—	—	—	5.9
94.6 94.6	4.8	2.4	50.0	8.8	2.5	9.8	9.4	9.7	6.6	2.0	69.0	54.0	4.8	3.8	79.2	2.0	3.1	5.5	6.4
89.5 89.5	5.0	2.2	44.0	8.4	2.3	9.6	9.4	9.8	6.8	1.9	71.0	47.0	4.0	4.3	107.5	1.9	3.1	5.0	6.7
87.5 87.5	4.9	2.4	48.9	8.8	2.0	9.8	9.6	10.2	7.1	2.5	72.0	60.0	4.4	4.2	95.4	2.5	3.5	5.2	6.1
102.7 102.8	5.5	2.2	40.0	8.5	2.1	9.8	9.0	9.4	7.5	2.3	64.0	52.5	5.0	4.1	82.0	2.5	3.3	5.6	6.8
97.4 102.8	5.0	2.0	40.0	8.7	2.3	9.7	9.4	9.7	6.8	1.8	69.5	53.0	4.7	4.2	89.4	1.8	3.5	5.5	6.1
94.4 91.9	4.6	2.2	47.8	8.4	2.5	8.8	9.0	9.5	6.3	1.9	75.5	70.0	4.0	3.6	90.0	1.9	3.0	5.0	5.7
87.5 87.5	4.7	2.9	61.7	9.4	2.3	10.4	9.9	10.2	6.8	2.3	69.0	58.0	4.9	4.5	91.8	2.2	3.4	5.3	6.8
88.9 94.1	4.9	2.4	48.9	8.6	2.5	9.7	9.4	9.8	7.0	2.2	70.0	54.5	4.9	4.0	81.6	2.2	3.4	5.7	6.6
89.7 94.6	4.9	2.2	44.9	8.4	2.2	9.2	8.9	9.7	6.7	2.0	73.5	57.0	4.6	4.1	89.1	1.9	3.1	5.3	6.1
105.7 105.7	5.4	2.2	40.7	9.0	2.3	10.2	9.7	9.8	7.3	2.1	65.5	51.0	4.8	4.3	89.6	2.1	3.2	5.8	6.6
86.8 86.8	4.8	2.4	50.0	8.6	2.4	9.5	9.2	10.0	6.9	2.2	73.0	59.5	4.6	3.9	84.8	2.1	3.1	5.4	5.9
97.3 100.0	5.1	2.4	47.1	8.8	2.4	9.4	9.4	10.2	7.0	2.0	75.5	68.0	4.4	—	—	2.0	3.2	4.9	5.9
89.1 91.9	6.7	2.4	35.8	9.4	2.5	10.2	10.2	10.6	6.8	2.1	74.0	61.0	4.4	4.1	93.2	2.0	3.6	5.4	6.2
— 100.0	5.3	2.4	45.3	10.0	2.4	11.0	10.7	10.6	7.3	2.4	67.0	59.0	5.2	4.7	90.4	2.3	3.2	5.9	7.2
100.0 100.0	4.2	1.9	45.2	8.2	1.7	9.0	9.0	9.4	6.0	1.8	74.5	60.0	4.0	3.4	85.0	1.9	3.2	4.8	5.7
100.0 100.0	4.9	2.2	44.9	8.5	2.7	9.3	9.1	9.8	6.8	2.1	73.0	61.0	4.3	4.1	95.3	1.9	3,2	4.9	6.1
— 97.3	4.5	2.8	62.2	8.5	2.6	9.8	9.1	9.4	6.4	2.0	67.0	44.5	4.9	—	—	1.9	2.9	—	—
91.7 97.1	4.6	2.4	52.2	8.2	2.3	9.2	8.6	8.8	6.6	2.3	65.0	56.0	4.3	4.0	93.0	2.1	3.0	5.2	6.0
102.9 105.9	4.7	2.3	48.9	8.3	1.7	9.0	8.8	9.0	6.2	1.5	69.5	58.0	4.4	3.8	86.4	1.5	3.1	5.2	5.8
97.1 97.1	4.5	2.5	55.5	8.6	2.3	9.4	9.2	9.4	6.3	1.8	70.5	60.0	4.5	4.0	88.9	1.9	3.3	5.0	6.0
100.0 100.0	4.5	2.3	51.1	8.4	2.1	9.6	9.0	9.2	6.3	2.0	67.0	47.0	4.0	3.6	90.0	1.9	3.1	5.3	5.6
89.5 91.9	4.8	2.5	52.1	8.9	2.4	10.0	9.6	10.0	6.4	1.9	71.0	50.0	4.9	—	—	1.8	3.0	5.3	—
100.0 103.0	4.4	2.2	50.0	8.2	2.0	9.0	8.8	9.2	5.9	1.7	72.5	56.0	4.2	3.2	76.2	1.6	3.0	4.9	5.4

TABLE II—LOWER JAWS

Fitted to Skulls

Catalogue Number	Height at Symphysis	Thickness at left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
PAUCARCANCHA					
♂4	3.0	1.7	10.2	3.3	116 114
8	3.4	1.7	9.8	3.5	115 113
12	3.8	1.4	10.3	3.4	104 109
16	3.6	1.5	10.2	3.5	115 113
30	3.4	1.4	10.6	3.2	119 119
37	3.1	1.3	9.8	2.7	110 112
40	3.6	1.6	9.7	3.2	110 109
46	3.4	1.5	9.2	3.2	112 112
47	2.9	1.7	8.5	3.5	110 111
48	3.8	1.6	9.6	3.4	117 115
55	3.5	1.7	9.0	3.5	103 103
75	3.3	1.4	9.4	3.4	116 117
85	3.0	1.8	9.4	3.5	—— 108
87	3.6	1.6	10.1	3.3	116 113
92	3.8	1.5	10.0	3.3	112 112
122	3.4	1.5	9.9	2.7	116 120
123	3.0	1.5	9.3	3.4	116 112
129	3.5	1.6	9.6	3.6	107 103
142	3.2	1.6	9.7	3.4	106 103
160	3.1	1.5	9.9	3.1	108 100
161	3.1	1.5	9.5	3.1	108 109
174	3.7	1.9	10.9	3.0	111 111
♀2	2.9	1.3	8.9	2.9	131 126
39	2.9	1.8	8.5	3.4	114 112
83	3.0	1.7	8.8	3.1	125 118
93	2.9	1.6	9.5	3.1	105 104
133	2.9	1.6	8.6	3.4	121 121
153	3.0	1.7	9.1	3.3	115 113
159	3.5	1.3	9.3	3.1	125 126
165	3.3	1.7	9.6	3.3	116 121
♂♀7	3.1	1.6	8.6	3.2	117 120
121	2.8	1.7	8.1	3.1	111 115
149	3.5	1.9	9.5	3.3	118 114
TORONTOY					
♂747	3.6	1.5	10.6	3.4	106 110
752	3.2	1.6	9.5	3.5	107 105
757	3.6	1.5	9.3	3.5	114 113
758	3.1	1.4	10.2	3.4	100 106

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂760	3.4	1.7	9.4	3.9	104 106
761	3.3	1.5	9.5	3.4	— 108
790	3.1	1.6	9.0	3.3	103 103
791	4.2	2.0	10.8	3.2	113 113
♀751	3.2	1.8	10.0	3.5	120 121
769	2.8	1.5	9.0	3.5	112 114
777	3.2	1.6	9.3	3.3	112 109
782	2.6	1.8	10.9	3.1	122 124
786	2.5	1.5	7.7	3.2	109 111

PATALLACTA

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂638	3.5	1.7	11.5	3.5	100 101
639	3.6	1.9	8.7	3.7	105 105

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
645	4.4	1.7	10.8	3.6	118 116
956	3.2	1.6	9.3	3.5	119 —
♀636	3.2	1.5	10.2	3.3	114 115
657	2.8	1.6	9.1	3.2	118 —

HUAROCONDO

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂923	3.5	1.5	9.9	3.2	115 —

HUATA

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂882	3.4	1.3	11.1	3.5	106 105

HUISPANG

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂921	3.3	1.7	9.5	2.9	114 114

SILLQUE

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂915	3.6	1.7	9.6	3.5	108 109

LOWER JAWS
Odd Lots

PAUCARCANCHA

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂193	3.6	1.9	9.7	2.8	123 131
194	3.3	1.7	7.2	3.7	115 109
197	3.6	1.5	10.5	2.8	127 127
199	3.5	1.7	10.2	3.7	116 106
201	3.3	1.0	10.6	3.0	119 —
202	3.2	1.6	9.7	3.3	108 107
204	3.3	1.8	10.4	3.7	111 109
205	3.1	1.9	8.5	3.7	110 107
206	3.4	1.6	10.8	3.3	111 112
207	2.8	1.6	11.1	3.2	— 111
208	3.6	1.7	9.7	3.2	122 123
209	3.7	1.9	11.1	3.3	107 116
210	4.0	1.6	11.0	3.0	114 119

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂211	3.3	1.5	9.0	3.0	103 —
212	3.6	1.6	10.4	3.1	120 130
213	3.3	1.7	10.1	3.1	113 105
214	2.8	1.6	11.5	3.2	105 108
215	3.5	1.8	9.4	3.2	106 109
216	3.2	1.6	9.9	3.1	— 112
217	3.3	1.7	10.2	3.2	110 111
218	3.3	1.7	9.2	3.0	110 112
219	3.4	1.7	10.7	3.4	108 110
222	3.3	1.8	9.7	3.4	119 112
242	3.8	1.9	9.3	3.1	120 124
255	3.6	1.7	10.1	2.7	120 120
♀192	2.8	1.4	10.1	3.1	116 116
196	3.4	1.1	8.5	3.0	115 111
221	3.2	1.6	9.6	3.0	119 120
223	2.9	1.6	8.9	3.4	121 118
224	3.1	1.5	8.9	2.8	120 115
226	2.8	1.5	8.6	3.0	125 121
227	3.1	1.5	9.5	3.3	116 116
228	2.8	1.8	9.6	3.4	107 107
230	3.0	1.4	8.6	2.8	121 122

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
231	3.0	1.7	7.8	3.2	110 110
232	3.1	1.6	8.3	3.1	116 113
233	2.5	1.8	8.5	3.0	114 112
234	3.1	1.5	8.3	3.0	121 115
235	2.7	1.4	9.0	3.2	115 115
236	2.7	1.6	8.7	2.8	115 115
237	3.1	1.4	9.6	2.9	— 123
239	—	1.6	8.1	2.8	123 —
241	3.2	1.8	9.1	3.4	119 117
245	2.9	1.7	8.7	3.1	110 110
246	3.2	1.8	9.4	3.0	124 126
247	2.8	1.6	9.4	2.7	118 117
249	3.4	1.7	8.6	2.9	123 —
252	2.8	1.5	9.5	3.0	110 110
254	2.7	1.5	9.6	2.6	114 117
♂♀					
195	3.5	1.9	9.4	3.4	127 124
198	3.1	1.6	9.7	3.2	110 110
200	3.5	1.6	9.2	3.3	111 109
203	3.1	1.7	9.6	2.9	111 109
220	3.6	1.6	8.6	3.1	115 117

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂ ♀					
225	—	1.8	9.7	3.2	110
					116
240	3.2	1.6	10.6	3.1	118
					113
243	3.0	1.7	8.9	3.1	114
					120
250	2.8	1.7	9.5	3.1	107
					108
251	3.0	1.7	8.7	3.3	112
					112
253	2.9	1.8	9.5	3.0	118
					118
PATALLACTA					
♂681	2.7	1.8	10.2	3.2	109
					111
682	3.5	1.7	9.0	3.7	112
					113
684	3.1	1.7	10.5	3.3	107
					108
685	3.6	1.9	10.3	3.5	116
					116
686	3.6	1.8	11.1	3.1	116
					114
♀676	2.7	1.5	8.6	3.3	117
					123
677	2.9	1.5	8.2	3.2	109
					110
679	2.5	1.5	8.3	2.7	118
					123

Catalogue Number	Height at Symphysis	Thickness at Left 2nd Molar	Bigoniac Diameter	Minimum Breadth of Left Ascending Ramus	Angle
♂ ♀					
678	2.8	1.5	9.0	3.4	113
					113
680	3.0	1.7	9.1	3.3	112
					113
683	3.0	1.5	10.1	3.0	102
					102
687	3.4	1.5	9.3	3.2	111
					109
TORONTOY					
♀792	3.2	1.6	9.4	3.3	104
					108
793	3.3	1.4	9.4	3.1	115
					115
794	2.8	1.7	9.5	3.2	110
					—
HUATA					
♂893	3.4	1.8	10.2	4.0	—
					110
894	3.2	1.9	9.5	3.7	109
					109
895	3.5	1.6	10.4	3.4	113
					116
896	3.5	1.6	9.7	3.4	118
					119
♀897	3.1	1.8	9.0	3.1	114
					119
898	2.9	1.6	8.7	3.4	—
					109

TABLE III—STERNUM

Catalogue Number	Total Length	Maximum Breadth of Manubrium	Maximum Breadth of Mesosternum	Manubrium Length	Sternal Index
PAUCARCANCHA					
♂123	12.9	5.6	3.5	4.1	27.1
160	13.1	5.8	4.9	4.4	37.4
282	14.7	5.9	5.7	4.0	38.8
563	13.0	5.8	5.0	4.2	38.5
♀39	12.1	5.1	3.7	3.8	30.6
165	13.2	5.1	3.9	4.5	29.5
325	14.0	4.9	3.6	4.4	25.7
TORONTOY					
♂786	13.9	5.6	3.4	4.4	24.5
790	14.7	5.2	4.5	3.8	30.6
813	15.9	6.5	3.6	4.5	22.6
820	15.2	5.9	4.0	4.0	26.3
♀782	13.3	4.8	3.7	3.9	27.8
783	12.0	5.3	3.0	3.8	25.0

Catalogue Number	Total Length	Maximum Breadth of Manubrium	Maximum Breadth of Mesosterium	Manubrium Length	Sternal Index
PATALLACTA					
♀726	12.5	5.7	3.2	3.9	25.6
HUATA					
♂882	16.4	6.2	4.4	4.7	26.8
HUISPANG					
♂921	15.1	5.6	4.6	4.6	30.5
HUAROCONDO					
♂923	16.7	6.0	4.5	5.0	26.9

TABLE IV—SCAPULA

Catalogue Number	Maximum Length	Maximum Breadth	Infraspinous Length	Scapular Index	Infraspinous Index	Scapulospinal Angle
PAUCARCANCHA						
♂123	9.1	14.5	10.2	62.8	70.3	89.0
	—	—	—	—	—	—
161	9.7	15.2	11.4	63.8	75.0	87.0
	9.6	15.2	11.0	63.8	72.3	88.0
174	10.8	15.2	11.7	71.0	76.9	92.0
	—	—	—	—	—	—
275	—	—	—	—	—	—
	10.0	15.0	11.0	66.6	73.3	84.0
282	10.4	16.3	11.7	63.8	72.4	78.0
	—	—	—	—	—	—
285	—	—	—	—	—	—
	10.6	16.1	12.0	65.8	74.4	86.0
304	—	—	—	—	—	—
	9.9	14.4	10.5	68.7	72.9	85.0
313	9.4	14.9	11.3	63.0	75.7	83.0
	—	—	—	—	—	—
368	10.3	16.1	12.3	63.9	76.4	86.0
	—	—	—	—	—	—
381	9.9	15.4	11.1	64.3	72.7	84.0
	—	—	—	—	—	—
♀165	9.1	14.1	10.9	64.5	77.3	88.0
	—	—	—	—	—	—
284	—	—	—	—	—	—
	8.6	13.0	9.9	66.1	76.1	90.0
286	—	—	—	—	—	—
	9.0	13.3	11.0	67.6	82.7	84.0
293	8.9	14.1	10.4	63.1	73.7	83.0
	9.0	13.9	10.4	64.7	74.8	87.0
333	9.9	12.7	9.7	77.9	76.3	84.0
	—	—	—	—	—	—
359	9.0	12.5	9.2	72.0	73.6	85.0
	—	—	—	—	—	—
♂♀						
280	10.2	14.2	10.1	71.8	71.1	85.0
	10.8	13.7	9.1	78.8	66.4	82.5
280a	9.4	14.4	11.3	65.3	78.5	87.0
	—	—	—	—	—	—
300	10.4	14.3	11.0	72.7	76.2	82.5
	—	—	—	—	—	—
TORTONTOY						
♂775	10.5	15.4	11.5	68.2	74.7	85.5
	10.4	16.0	11.5	65.0	72.0	85.5
790	—	—	—	—	—	—
	10.7	14.3	11.4	74.8	72.7	83.0
854	10.1	15.7	11.7	64.3	74.5	87.0
	10.1	15.6	12.0	64.7	76.9	87.5
854a	10.6	15.8	11.3	67.0	72.0	79.0
	—	—	—	—	—	—
854c	9.8	15.1	11.5	64.9	76.2	82.0
	—	—	—	—	—	—
♀782	10.0	13.7	10.4	73.0	76.0	83.0
	9.8	13.8	10.6	71.0	77.0	86.0
854d	9.5	13.3	9.8	71.4	73.7	83.0
	—	—	—	—	—	—
♂853	—	—	—	—	—	—
	9.4	15.0	11.7	62.6	78.0	87.0
HUATA						
♂882	11.3	15.5	10.0	72.9	77.4	81.0
	11.3	16.1	12.1	70.2	75.1	89.0
HUISPANG						
♂921	9.7	15.3	11.5	63.4	75.2	87.0
	9.4	15.4	11.7	61.0	75.3	90.0
HUAROCONDO						
♂923	10.9	17.1	12.4	63.7	72.5	81.0
	—	—	—	—	—	—

TABLE V—HUMERUS

Number	Maximum Length	Breadth of Upper Epiphysis	Breadth of Lower Epiphysis	Minimum Circumference	Cubital Angle	Index of Robusticity
PAUCARCANCHA						
♂						
123r	29.5	4.6	6.0	5.6	84.0	18.9
1	29.0	4.7	6.0	5.3	84.0	18.0
160	30.0	4.8	6.0	5.8	82.5	19.3
	29.7	4.5	5.7	5.5	81.5	18.5
161	29.0	4.5	5.4	5.4	82.5	18.6
	—	—	—	—	—	—
174	31.2	5.0	6.5	5.6	79.0	17.9
	—	—	—	—	—	—
189	—	—	—	—	—	—
	29.9	4.9	6.1	5.5	82.5	18.4
275	—	—	—	—	—	—
	29.8	4.3	5.9	5.2	83.0	17.4
280	28.0	4.7	6.3	5.4	84.0	19.3
	27.7	4.4	6.3	5.5	80.0	19.8
282	29.1	4.8	6.0	5.7	84.0	19.6
	—	—	—	—	—	—
292	30.1	5.0	6.0	5.8	82.0	19.3
	—	—	—	—	—	—
294	27.4	4.8	6.1	5.9	86.0	21.5
	—	—	—	—	—	—
298	—	—	—	—	—	—
	28.1	4.1	6.0	5.5	83.0	19.6
299	25.3	4.6	5.7	5.3	90.0	20.9
	24.7	4.4	5.7	5.4	90.0	21.9
302	—	—	—	—	—	—
	27.4	4.7	6.0	5.7	87.0	20.8
313	27.4	4.8	5.8	5.5	85.5	20.0
	—	—	—	—	—	—
349	—	—	—	—	—	—
	28.7	4.8	5.9	5.9	86.0	20.5
370	31.7	5.0	—	5.6	79.0	17.6
	—	—	—	—	—	—
381	30.5	4.5	5.8	5.5	84.0	18.0
	—	—	—	—	—	—
522	29.6	5.0	5.9	5.5	87.0	18.6
	—	—	—	—	—	—
523	31.7	4.7	6.3	6.3	80.0	19.5
	—	—	—	—	—	—

Number	Maximum Length	Breadth of Upper Epiphysis	Breadth of Lower Epiphysis	Minimum Circumference	Cubital Angle	Index of Robusticity
572	28.3	4.8	6.1	5.7	79.5	20.1
	—	—	—	—	—	—
♀39	26.0	3.9	4.8	4.7	79.0	18.0
	26.1	4.0	4.8	4.7	82.0	18.0
165	27.5	4.0	5.2	4.9	83.5	17.8
	—	—	—	—	—	—
273	26.9	4.6	5.4	4.9	86.0	18.2
	—	—	—	—	—	—
281	26.7	4.0	5.1	4.6	80.0	17.2
	—	—	—	—	—	—
284	—	—	—	—	—	—
	25.3	4.1	5.1	4.8	82.0	18.9
296	26.9	4.7	5.4	5.1	85.5	18.9
	26.1	4.5	5.5	4.9	85.5	18.8
299b	—	—	—	—	—	—
	27.0	4.0	4.9	4.5	87.0	16.6
333	27.4	4.5	5.1	5.1	81.0	18.6
	—	—	—	—	—	—
359	26.0	4.1	5.3	4.8	88.0	18.5
	—	—	—	—	—	—
♂♀						
325	—	—	—	—	—	—
	27.4	4.4	5.7	5.0	86.0	18.2
571	—	—	—	—	—	—
	26.4	4.4	5.3	5.1	82.0	19.3
573	29.0	4.5	5.4	5.2	78.5	17.9
	—	—	—	—	—	—
TORONTOY						
♂774	30.5	5.1	6.1	6.1	82.0	20.0
	29.9	4.8	6.2	5.5	84.0	18.4
775	27.4	5.1	6.2	5.9	87.0	21.5
	—	—	—	—	—	—
786a	27.4	5.0	6.1	6.0	82.0	21.9
	—	—	—	—	—	—
788	29.3	4.9	6.2	5.9	81.5	20.1
	—	—	—	—	—	—
790	28.0	4.6	5.7	5.3	82.5	18.9
	28.1	4.7	5.6	5.1	85.0	18.1

Number	Maximum Length	Breadth of Upper Epiphysis	Breadth of Lower Epiphysis	Minimum Circumference	Cubital Angle	Index of Robusticity
795	——	——	——	——	——	——
	28.5	5.1	6.5	6.1	86.0	21.4
797	——	——	——	——	——	——
	29.1	4.9	6.1	5.6	80.0	19.2
798	28.3	4.9	6.3	5.8	83.5	20.5
	——	——	——	——	——	——
♀ 772	26.2	3.6	4.8	4.6	79.0	17.5
	26.2	3.7	4.8	4.6	81.0	17.5
777	——	——	——	——	——	——
	27.3	4.3	5.1	4.9	87.5	17.9
782	29.2	4.2	5.1	5.3	79.5	18.1
	29.0	4.1	5.2	5.2	80.0	17.9
783	27.1	4.2	5.2	4.7	84.5	17.3
	26.8	4.1	5.1	4.7	83.0	17.5
844	27.7	4.3	5.5	5.0	——	18.0
	27.4	4.2	5.5	5.0	82.0	18.2
♂ ♀						
776	——	——	——	——	——	——
	30.3	4.7	6.1	5.3	83.5	17.5
853	——	——	——	——	——	——
	27.0	4.5	6.0	5.4	81.0	20.0
PATALLACTA						
♂						
1007r	——	——	——	——	——	——
1	30.8	4.9	6.1	5.5	83.5	17.8

Number	Maximum Length	Breadth of Upper Epiphysis	Breadth of Lower Epiphysis	Minimum Circumference	Cubital Angle	Index of Robusticity
♀						
1009	24.2	4.2	5.3	4.7	79.0	19.4
	——	——	——	——	——	——
HUATA						
♂						
882	29.6	5.2	5.8	6.1	81.0	20.6
	——	——	——	——	——	——
882a	——	——	——	——	——	——
	28.7	4.9	5.7	5.7	82.0	19.9
903	30.5	4.7	5.5	5.4	81.5	17.7
	——	——	——	——	——	——
♀						
910	28.2	4.4	5.4	5.1	82.0	18.1
	——	——	——	——	——	——
HUISPANG						
♂						
921	28.2	4.8	5.5	5.3	80.0	18.8
	27.5	4.7	5.4	5.2	83.0	18.9
HUAROCONDO						
♂						
923	31.5	5.0	6.5	5.9	83.0	18.7
	30.3	5.4	6.3	5.9	86.0	19.5

TABLE VI—RADIUS

Catalogue Number	Maximum Length	Physiological Length	Minimum Circumference	Radio-Humeral Index	Caliber Index
PAUCARCANCHA					
♂123	22.2	20.9	3.6	75.3	17.2
	22.2	20.9	3.8	76.5	18.2
160	—	—	—	—	—
	22.9	21.9	3.9	77.1	17.8
161	21.9	20.8	3.5	75.5	16.8
	—	—	—	—	—
275	21.9	20.8	4.0	73.8	19.2
	—	—	—	—	—
282	22.7	21.5	4.0	78.0	18.6
	—	—	—	—	—
292	23.4	22.5	3.8	75.5	16.9
	—	—	—	—	—
294	22.8	21.5	4.1	83.2	19.1
	—	—	—	—	—
298	—	—	—	—	—
	22.3	20.6	3.8	79.3	18.4
299	18.8	17.5	3.4	74.3	19.4
	18.8	17.6	3.4	76.1	19.3
299a	21.2	20.0	3.7	—	18.5
	—	—	—	—	—
302	—	—	—	—	—
	22.2	21.0	3.7	81.0	17.6
311	—	—	—	—	—
	23.6	22.1	3.4	—	15.3
313	21.2	19.8	3.6	77.3	18.2
	—	—	—	—	—
317	—	—	—	—	—
	21.3	20.1	3.4	—	16.1
327	22.8	21.6	3.7	—	17.1
	—	—	—	—	—
348	—	—	—	—	—
	22.2	21.3	3.4	—	15.9
349	21.8	20.6	3.6	75.9	17.4
	—	—	—	—	—
366	—	—	—	—	—
	23.0	21.7	3.7	—	17.0
368	21.0	19.9	3.3	—	16.6
	—	—	—	—	—
380	22.4	21.6	3.5	—	16.2
	—	—	—	—	—
381	22.3	21.5	3.3	73.1	15.3
	—	—	—	—	—
382	23.0	21.9	3.5	—	15.9
	—	—	—	—	—
467	23.5	22.2	4.0	—	18.0
	23.3	22.2	3.6	—	16.2
562	22.1	20.8	3.2	—	15.5
	—	—	—	—	—
	—	—	—	—	—
565	21.6	20.3	3.9	—	19.2
♀39	19.3	18.4	3.1	74.2	16.8
	19.3	18.3	3.1	73.9	16.9
278	19.8	18.8	3.3	—	17.5
	—	—	—	—	—
296	21.4	20.2	3.5	79.5	17.3
	20.8	19.8	3.6	79.7	18.1
299b	—	—	—	—	—
	18.9	18.2	3.1	70.0	17.0
336	19.2	18.3	2.9	—	15.9
	—	—	—	—	—
340	—	—	—	—	—
	20.3	19.5	3.0	—	15.4
341	—	—	—	—	—
	19.5	18.6	3.0	—	16.1
564	—	—	—	—	—
	19.7	18.7	3.1	—	16.5
♂♀ 369	20.3	19.7	3.1	—	15.7
	—	—	—	—	—
TORONTOY					
♂774	23.5	22.2	3.5	77.0	15.8
	—	—	—	—	—
775	22.0	20.7	3.5	80.3	16.9
	21.7	20.4	3.4	—	16.7
776	—	—	—	—	—
	23.5	22.1	3.5	—	15.8
781	—	—	—	—	—
	23.6	22.3	3.5	—	15.7

Catalogue Number	Maximum Length	Physiological Length	Minimum Circumference	Radio-Humeral Index	Caliber Index
786a	20.5	19.3	3.9	74.8	20.2
	—	—	—	—	—
790	21.8	20.7	3.3	77.8	15.9
	21.6	20.5	3.3	76.8	16.1
795	—	—	—	—	—
	22.2	21.1	3.7	77.9	17.5
796	22.4	21.2	3.6	—	16.9
	—	—	—	—	—
808	22.5	21.3	3.8	—	17.8
	—	—	—	—	—
809	24.4	23.2	3.9	—	16.8
	—	—	—	—	—
824	—	—	—	—	—
	22.5	21.4	3.6	—	16.8
825	—	—	—	—	—
	22.9	21.9	3.2	—	14.6
832	—	—	—	—	—
	23.7	22.4	3.8	—	16.9
834	—	—	—	—	—
	21.7	20.3	3.2	—	15.7
♀772	—	—	—	—	—
	19.8	19.0	2.9	75.6	10.5
777	21.1	20.0	3.2	77.2	16.0
	—	—	—	—	—
782	20.3	19.1	3.5	69.5	18.3
	20.2	19.0	3.5	69.7	18.4
783	20.8	19.9	3.1	76.7	15.6
	20.7	19.7	3.0	77.2	15.2
806	—	—	—	—	—
	19.2	18.2	2.9	—	15.9
	21.3	20.2	3.1	—	15.3
840	—	—	—	—	—

Catalogue Number	Maximum Length	Physiological Length	Minimum Circumference	Radio-Humeral Index	Caliber Index
♂♀					
807	22.7	21.5	3.2	—	14.9
	—	—	—	—	—
853	—	—	—	—	—
	20.8	19.6	3.5	77.0	17.8

HUATA

♂908	22.4	21.3	3.6	—	16.9
	—	—	—	—	—
♀910	20.1	19.1	3.2	71.2	16.7
	—	—	—	—	—
♂♀ 906	—	—	—	—	—
	21.7	20.6	3.3	—	16.0
907	—	—	—	—	—
	21.0	19.9	3.5	—	17.6

HUISPANG

♂921	22.2	21.0	3.4	78.7	16.2
	22.0	21.0	3.4	80.0	16.2

HUAROCONDO

♂923	22.8	21.4	4.0	72.3	18.7
	22.7	21.3	3.9	74.9	18.3

PATALLACTA

♀689	—	—	—	—	—
	19.6	18.7	3.0	—	16.0

TABLE VII—ULNA

Catalogue Number	Maximum Length	Physiological Length	Minimum Circumference	Caliber Index
PAUCARCANCHA				
♂123	24.1	21.3	3.4	15.9
	24.1	21.3	3.3	15.5
160	24.7	22.1	3.4	15.4
	——	——	——	——
161	23.2	20.5	3.3	16.1
	——	——	——	——
275	23.5	21.0	3.0	14.3
	——	——	——	——
282	24.7	21.7	3.4	15.6
	——	——	——	——
292	25.2	22.6	3.2	14.1
	——	——	——	——
294	25.2	22.5	3.5	15.5
	——	——	——	——
298	——	——	——	——
	24.1	21.3	3.4	15.9
299	20.8	18.2	3.3	18.1
	20.8	18.2	3.3	18.1
299a	23.7	20.8	3.3	15.8
	——	——	——	——
302	——	——	——	——
	24.0	21.3	3.3	15.5
311	——	——	——	——
	25.4	22.8	3.5	15.4
313	——	20.3	3.5	17.2
	——	——	——	——
317	——	——	——	——
	23.3	20.7	3.2	15.4
337	23.7	20.9	3.2	15.3
	——	——	——	——
348	——	——	——	——
	23.9	21.5	3.0	13.9
349	——	——	——	——
	23.3	20.5	3.0	14.6
366	——	——	——	——
	25.2	22.2	3.2	14.4
368	22.8	21.1	2.9	17.4
	——	——	——	——
381	24.2	21.7	2.9	13.3
	——	——	——	——
382	25.1	22.4	3.3	14.7
	——	——	——	——
467	25.2	22.5	3.5	15.5
	24.9	22.3	3.3	14.8
562	23.8	21.1	3.0	14.2
	——	——	——	——
♀39	21.0	18.5	2.8	15.1
	20.8	18.5	2.9	15.7
296	22.8	20.4	3.4	16.6
	22.5	20.0	3.3	16.5
299b	——	——	——	——
	20.7	18.6	2.8	15.1
336	21.0	18.9	2.7	14.3
	——	——	——	——
340	——	——	——	——
	22.2	19.8	2.8	14.1
♂♀ 369	——	21.1	3.0	14.2
	——	——	——	——
TORTONTOY				
♂774	25.7	22.9	3.4	14.8
	——	——	——	——
775	23.7	21.0	3.4	16.2
	23.7	20.9	3.4	16.2
778	26.1	23.5	3.0	12.8
	——	——	——	——
781	——	——	——	——
	25.8	23.1	3.3	14.3
786	21.9	19.6	3.3	16.8
	——	——	——	——
790	23.7	21.3	2.9	13.6
	23.5	21.2	2.9	13.7
795	——	——	——	——
	24.6	21.9	3.4	15.5
796	25.0	22.1	3.6	16.3
	——	——	——	——

Catalogue Number	Maximum Length	Physiological Length	Minimum Circumference	Caliber Index
824	——	——	——	——
825	24.4	21.0	3.2	15.2
	——	——	——	——
832	24.8	22.2	2.9	13.1
	——	——	——	——
834	25.5	22.9	3.3	14.4
	——	——	——	——
	23.0	20.5	3.2	15.6
♀772	21.6	19.3	2.6	13.5
	——	——	——	——
777	22.8	20.4	2.8	13.7
	——	——	——	——
782	21.7	19.4	3.4	17.5
	21.7	19.4	2.9	14.9
783	22.8	20.6	2.9	14.1
	22.7	20.4	2.8	13.7
840	23.5	20.9	3.0	14.3
	23.3	20.9	2.9	13.9
PATALLACTA				
♂734	26.3	23.5	3.4	14.5
	——	——	——	——
735	26.9	23.9	3.8	15.9
	——	——	——	——
1010	24.6	22.1	3.0	13.5
	——	——	——	——
♀689	——	——	——	——
	21.2	18.8	2.9	15.4
HUATA				
♂908	23.8	21.4	3.3	15.4
	——	——	——	——
♀910	22.3	19.8	3.0	15.1
	——	——	——	——
HUISPANG				
♂921	23.5	21.1	3.4	15.1
	23.2	21.0	3.4	16.2
HUAROCONDO				
♂923	24.8	21.7	3.6	16.6
	——	21.7	3.4	15.6

TABLE VIII—LUMBAR INDICES

Catalogue Number	I	II	III	IV	V	Lumbo-vertebral Index
PAUCARCANCHA						
♂75	100.0	90.9	90.9	81.8	90.9	97.2
281	100.0	110.5	116.6	86.4	69.2	99.0
297	113.6	108.3	92.6	92.6	79.0	96.0
388	109.0	108.3	104.1	104.5	70.0	98.3
627	114.4	107.5	106.1	100.0	84.6	102.4
♀39	112.5	112.5	112.5	104.0	77.0	103.2
165	118.0	109.0	100.0	88.4	74.0	96.7
281a	96.0	96.0	96.0	84.6	71.4	88.4
293	108.3	104.0	110.5	100.0	77.0	99.6
♂ ♀						
310	117.0	108.3	103.8	96.1	78.6	100.0
575	108.7	100.0	100.0	96.0	77.0	95.9
TORONTOY						
♂						
789	117.4	107.7	100.0	92.3	71.4	96.8
790	121.0	114.3	109.5	95.5	78.3	102.7
862	118.1	118.1	108.3	96.1	78.8	102.4
♀						
777	109.0	104.3	96.1	92.3	88.5	97.5
782	108.3	108.0	96.4	100.0	88.5	100.0
783	109.0	104.6	96.0	92.0	73.0	94.1
HUATA						
♀						
910	108.3	100.0	100.0	88.8	78.6	94.6
HUISPANG						
♂						
921	108.3	107.7	103.7	100.0	92.3	102.3

TABLE IX—SACRUM

Catalogue Number	Straight Length	Maximum Breadth	Depth of Curve	Curved Length	Sacrum Index
PAUCARCANCHA					
♂123	10.2	9.9	1.1	10.8	97.0
279	9.9	10.0	1.8	10.8	101.0
283	9.1	11.0	1.4	9.8	120.9
290	11.2	11.4	0.9	11.3	101.8
297	8.6	10.7	1.5	8.9	124.4
368	10.1	10.9	1.9	11.3	107.9
388	9.0	11.0	1.1	9.6	122.2
390	10.8	10.9	1.1	11.3	100.9
438	9.7	11.0	1.3	10.5	113.4
463	10.1	11.5	0.7	10.7	113.8
627	11.1	10.3	1.5	12.0	92.8
♀39	9.2	11.8	1.7	9.9	128.3
190	10.7	——	0.8	10.8	——
276	8.9	11.3	2.0	9.9	126.9
281a	9.3	10.9	1.5	10.2	117.2
291	8.9	10.9	2.0	9.8	122.5
293	8.0	11.1	1.6	8.8	138.7
295	8.1	10.2	1.6	8.9	125.9
301	7.6	8.8	2.0	8.8	115.8
330	8.9	12.0	1.8	9.6	134.8
439	8.0	9.7	1.8	9.0	121.3
461	9.8	11.3	1.8	10.3	115.3
462	8.6	11.3	1.6	9.5	131.4
463c	8.3	11.3	1.7	9.4	136.1
463d	8.8	11.4	2.0	10.0	129.5
♂♀					
463a	9.0	10.8	1.7	9.8	120.0
463b	9.7	10.6	1.2	10.0	109.3
PATALLACTA					
♂702	11.0	11.5	2.3	12.1	104.5
703	9.2	11.2	2.0	10.9	121.7
720	9.9	11.5	0.9	10.5	116.1
1025	12.3	11.8	-1.2	13.0	95.9
1026	10.2	11.3	1.0	10.5	110.8
1029	10.1	11.2	1.6	11.3	110.9
♀719	8.3	11.4	2.3	9.2	137.3
724	9.3	10.6	1.4	9.7	113.9
725	8.0	10.4	1.9	9.2	130.0
1028	8.3	10.8	2.2	9.4	130.1
1048	9.1	12.1	1.6	10.0	132.9
TORONTOY					
♂776	9.7	10.7	1.3	10.3	110.3
786a	11.2	11.5	1.3	11.5	102.7
788	9.4	10.3	1.3	9.7	109.6
789	10.4	12.1	2.0	16.3	116.3
862	12.0	11.5	1.0	12.5	95.8
876	10.5	10.8	2.1	11.5	102.9
♀778	9.7	10.2	1.5	10.3	105.2
782	10.1	11.0	1.5	10.9	108.9
831	10.1	11.0	1.9	10.5	108.9
♂♀					
787	9.8	10.3	1.8	10.5	105.1
HUATA					
♂882	10.0	11.2	1.4	10.7	112.0
♀910	8.2	12.0	1.9	9.1	146.3
HUISPANG					
♂921	11.4	10.5	1.3	12.0	92.1
HUAROCONDO					
♂923	11.7	11.6	1.5	12.2	99.1

TABLE X—PELVIS

Catalogue Number	Height	Breadth	External Sagittal Diameter	Acetabular Breadth	Height of Symphysis	Sagittal Diameter of Brim	Transverse Diameter of Brim	Sagittal Diameter Pelvic Exit	Transverse Diameter Pelvic Exit	Sub-pubic Angle	Breadth-Height Index	Index of Brim
PAUCARCANCHA												
♂123	18.8	25.1	14.5	11.7	3.1	9.2	12.0	7.2	6.8	46.0	74.9	76.7
274	20.9	25.8	15.0	12.6	3.8	10.2	12.5	9.6	7.0	40.5	81.0	81.6
279	18.9	25.1	14.9	11.4	3.2	8.7	12.3	9.0	6.5	42.0	75.3	71.5
283	19.3	27.8	15.9	11.4	3.4	8.9	12.1	10.2	6.1	38.0	69.4	73.5
368	19.9	26.6	16.6	12.7	3.8	9.4	12.0	9.6	8.1	53.0	74.8	78.3
388	18.7	26.4	14.9	12.6	3.4	8.2	12.0	9.4	7.9	47.5	70.8	68.3
438	19.3	25.8	14.7	11.4	3.5	8.6	11.6	9.6	6.2	34.0	74.8	74.1
627	20.2	24.8	16.3	11.8	3.2	11.0	11.4	9.4	6.6	38.5	81.4	96.5
♀39	18.0	24.9	16.3	14.1	3.1	11.5	13.6	10.8	10.8	81.0	72.3	84.5
276	18.5	25.5	14.9	13.7	3.5	9.4	13.5	10.1	9.3	67.0	72.6	69.6
281a	18.9	26.5	16.0	12.9	3.3	10.3	12.5	9.6	9.6	74.0	71.3	82.4
291	16.6	23.2	15.6	13.0	2.8	9.8	12.0	10.7	11.0	90.0	71.5	81.7
293	17.8	24.6	14.3	13.6	3.6	8.4	12.7	9.6	10.4	77.0	72.4	66.1
295	19.9	27.6	15.7	13.7	3.8	9.9	12.4	9.1	8.9	62.0	72.1	79.8
301	16.6	24.1	14.3	12.4	3.9	7.9	12.7	9.3	9.4	74.0	68.9	62.2
330	18.9	24.8	15.7	13.2	3.4	9.8	12.5	10.8	9.0	65.0	76.2	78.4
439	16.1	22.9	15.2	12.3	3.2	9.6	11.6	9.8	8.2	69.0	70.3	82.7
461	18.8	27.3	15.8	13.8	3.6	11.3	14.2	9.6	10.2	68.5	68.9	79.6
462	18.0	26.3	16.2	13.4	3.4	9.3	13.2	11.4	10.1	62.0	68.4	70.4
TORONTOY												
♂776	20.2	——	16.0	12.0	3.2	10.2	12.0	10.1	8.3	52.0	——	85.0
789	21.0	27.1	14.4	13.4	3.9	8.6	12.7	10.0	7.8	45.0	77.5	67.7
790	19.3	23.3	15.1	11.0	3.2	10.6	10.9	——	6.6	49.0	82.8	97.2
862	19.9	24.6	16.3	12.4	3.7	10.7	12.1	10.6	8.0	51.0	80.9	88.4
876	20.6	24.6	15.7	11.9	3.7	9.9	12.1	10.5	7.9	——	83.7	81.8
♀778	18.3	22.6	15.9	12.7	3.4	9.5	12.8	10.9	8.6	63.0	80.9	74.2
782	20.0	26.9	15.6	13.9	4.5	10.1	13.5	11.7	9.1	73.0	74.3	74.8
831	18.7	23.1	14.1	13.3	4.0	10.3	12.0	12.0	9.2	67.0	80.9	85.8
♂787	18.7	23.1	14.6	11.6	3.4	9.2	11.9	9.2	7.1	50.0	80.9	77.3

Catalogue Number	Height	Breadth	External Sagittal Diameter	Acetabular Breadth	Height of Symphysis	Sagittal Diameter of Brim	Transverse Diameter of Brim	Sagittal Diameter Pelvic Exit	Transverse Diameter Pelvic Exit	Sub-pubic Angle	Breadth-height	Index Index of Brim
PATALLACTA												
♂702	21.2	28.4	16.3	13.0	4.0	9.0	12.8	9.2	7.0	44.5	74.6	70.3
788	18.7	24.5	13.4	12.0	3.4	8.8	11.8	8.0	7.6	50.5	76.3	74.6
1029	20.0	27.0	16.1	12.3	4.1	10.0	13.1	10.0	7.0	44.0	74.1	76.3
HUATA												
♀910	19.4	27.8	16.5	14.4	4.1	10.3	13.4	11.1	9.9	67.5	69.8	76.9
HUISPANG												
♂921	19.9	26.8	17.6	13.0	3.7	11.3	12.4	10.2	9.0	61.0	74.3	91.1
HUAROCONDO												
♂923	21.5	28.5	17.2	12.5	4.3	10.5	13.0	9.5	6.4	40.0	75.4	80.[illegible]

TABLE XI—FEMUR

Catalogue Number	Side	Maximum Length	Oblique Length	Shaft Length	Antero-posterior Diameter	Transverse Diameter	Circumference	Upper Transverse Diameter	Upper Antero-posterior Diam.	Maximum Vertical Diameter of Caput	Angle of Torsion	Femoro-Humeral Index	Pilastric Index	Caliber Index	Index of Platymeria
PAUCARCANCHA															
♂123	r	39.7	39.2	31.7	2.3	2.2	7.0	3.0	1.9	4.3	22.0	75.2	104.5	17.6	63.3
	l	40.0	40.0	32.0	2.3	2.3	7.1	3.1	1.9	4.3	29.0	72.5	100.0	17.7	61.3
160	r	40.0	39.6	32.2	2.7	2.5	8.2	3.3	2.2	4.2	19.0	75.7	108.0	20.7	66.7
	l	39.0	39.2	32.0	2.6	2.5	8.0	3.2	2.1	4.2	20.0	75.8	104.0	20.4	63.7
268	r	39.2	38.8	31.3	2.5	2.5	7.5	3.1	2.1	4.5	18.0	—	100.0	19.3	67.7
	l	39.0	38.9	31.3	2.5	2.5	7.6	3.2	2.1	4.4	19.0	—	100.0	19.5	65.6
277		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	38.4	37.2	29.8	2.5	2.2	7.0	2.8	1.9	4.2	25.0	—	113.7	18.4	67.9
290	r	41.3	41.1	32.2	2.6	2.7	8.0	3.6	2.0	4.7	26.0	—	96.3	19.5	55.5
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
332		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	39.9	39.5	—	2.4	2.5	7.7	3.2	2.0	4.5	36.0	—	92.4	19.5	62.5
334	r	41.7	41.3	32.9	2.4	2.2	7.4	3.4	2.0	4.6	30.0	—	109.1	17.9	58.8
	l	42.4	41.7	33.2	2.5	2.4	7.5	3.5	2.0	4.6	30.0	—	104.1	18.0	57.1
346	r	36.8	36.6	28.8	2.1	1.9	6.4	2.7	1.9	4.1	27.0	—	110.5	17.5	70.4
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
353		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	42.3	41.8	34.2	2.4	2.2	6.9	2.9	1.9	4.0	29.0	—	109.1	16.5	65.5
357	r	40.0	39.4	31.3	2.3	2.5	7.7	3.2	1.9	4.6	30.0	—	92.0	19.5	59.4
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
368	r	39.8	39.6	31.3	2.3	2.3	7.4	3.2	2.0	4.3	23.0	—	100.0	18.7	62.5
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
460	r	33.3	33.1	26.2	1.9	2.3	6.7	3.1	1.7	4.1	32.0	—	87.0	20.6	54.8
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
467	r	37.6	37.4	29.7	2.5	2.1	7.0	2.9	1.9	4.1	21.0	—	119.0	18.7	65.5
	l	38.0	37.8	30.0	2.5	2.0	7.0	2.9	1.9	4.0	21.0	—	125.0	18.3	65.5
468	r	38.2	37.7	30.0	2.5	2.4	7.4	2.9	2.0	4.3	19.0	—	104.1	19.6	69.0
	l	38.4	37.9	30.3	2.6	2.2	7.5	2.7	2.0	4.4	20.0	—	118.2	19.8	74.1
470		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	37.3	37.2	29.7	2.5	2.2	7.3	2.9	1.9	4.1	22.0	—	113.6	19.6	65.5
471		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	39.4	38.9	30.7	2.6	2.3	7.6	3.1	2.0	4.4	30.0	—	113.0	19.5	64.5
472		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	38.2	37.9	31.3	2.6	2.4	7.9	3.1	2.0	4.1	21.0	—	108.3	20.8	64.5
473		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	39.2	38.9	31.3	2.3	2.4	7.1	3.1	1.9	4.3	21.0	—	95.8	18.2	61.3
474		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	41.1	40.8	33.5	2.5	2.4	7.6	3.3	2.0	4.5	30.0	—	104.2	18.6	60.6

Catalogue Number	Side	Maximum Length	Oblique Length	Shaft Length	Antero-posterior Diameter	Transverse Diameter	Circumference	Upper Transverse Diameter	Upper Antero-posterior Diam.	Maximum Vertical Diameter of Caput	Angle of Torsion	Femoro-Humeral Index	Pilastric Index	Caliber Index	Index of Platymeria
PAUCARCANCHA															
475	l	40.2	40.0	31.0	2.3	2.5	7.6	3.2	2.0	4.5	25.0	——	92.0	19.0	62.5
476	l	40.7	40.2	32.6	2.6	2.5	7.7	3.1	2.1	4.3	19.0	——	104.0	19.1	67.7
477	l	38.5	37.9	31.0	2.3	2.0	6.6	2.8	1.7	4.1	31.0	——	115.0	17.4	60.7
478	l	39.8	39.3	32.0	2.5	2.4	7.6	3.2	2.2	4.2	21.0	——	104.1	19.3	68.7
480	l	40.7	40.2	33.5	2.5	2.4	7.7	3.1	2.0	4.2	22.0	——	104.1	19.1	64.5
481	l	43.0	42.5	34.7	2.6	2.6	7.9	3.6	2.1	4.5	19.0	——	100.0	18.6	58.3
482	l	43.3	42.9	35.1	2.8	2.7	8.5	3.5	2.3	4.5	25.0	——	103.7	19.8	65.7
483	l	42.1	41.9	34.2	2.8	2.4	8.1	3.2	2.1	4.2	34.0	——	116.7	19.3	65.6
484	l	38.5	38.4	31.3	3.0	2.2	7.8	2.9	1.9	4.3	26.0	——	136.4	20.3	65.5
485	l	37.7	37.5	29.4	2.2	2.4	7.1	3.0	1.8	4.1	30.0	——	91.7	17.3	60.0
486	l	36.0	35.6	27.5	2.4	2.2	7.0	2.9	1.8	4.2	13.0	——	109.1	19.7	62.1
487	r	40.6	40.1	32.3	2.7	2.4	8.0	3.1	2.0	4.3	12.0	——	112.5	19.9	64.5
488	r	42.1	42.0	34.2	2.9	2.4	8.2	3.2	2.0	4.2	30.0	——	120.8	19.5	62.5
489	r	42.3	42.2	34.2	2.5	2.6	7.9	3.5	2.1	4.7	5.0	——	96.2	18.6	60.0
490	r	41.4	41.1	34.2	2.7	2.4	7.8	3.2	2.1	4.3	21.0	——	112.5	19.0	65.6
491	r	42.9	42.6	35.1	2.6	2.7	8.3	3.5	2.3	4.4	24.0	——	96.3	19.5	65.7
492	r	40.7	40.1	32.3	2.5	2.3	7.3	3.0	1.8	4.4	30.0	——	108.7	18.2	60.0
495	r	41.0	40.9	33.9	2.3	2.4	7.5	3.4	2.0	4.4	27.0	——	95.8	18.3	58.8
496	r	39.3	38.9	31.6	2.7	2.4	7.8	3.1	2.0	4.7	25.0	——	112.5	20.0	64.5
501	r	39.4	39.1	31.3	2.6	2.4	7.8	3.2	2.2	4.3	20.0	——	108.3	19.9	68.7
502	r	40.9	40.4	31.5	2.5	2.4	7.5	3.2	2.0	4.7	22.0	——	104.1	18.6	62.5

Catalogue Number	Side	Maximum Length	Oblique Length	Shaft Length	Antero-posterior Diameter	Transverse Diameter	Circumference	Upper Transverse Diameter	Upper Antero-posterior Diameter	Maximum Vertical Diameter of Caput	Angle of Torsion	Femoro-Humeral Index	Pilastric Index	Caliber Index	Index of Platymeria
PAUCARCANCHA															
506	r	38.5	38.0	30.2	2.6	2.3	7.3	2.9	1.8	4.2	26.0	—	113.0	19.2	62.1
511	r	39.1	38.5	31.3	2.5	2.4	7.3	3.1	1.9	4.4	18.0	—	104.1	19.0	61.3
512	r	37.0	36.7	29.4	2.3	2.0	6.4	2.6	1.8	4.1	16.0	—	115.0	17.4	69.2
627	r	40.7	40.3	32.9	2.2	2.9	7.9	3.2	2.1	4.4	31.0	—	75.9	19.6	65.6
	l	40.9	40.5	32.9	2.4	2.8	7.9	3.1	2.1	4.3	29.0	—	85.7	19.5	67.7
♀39	r	35.9	35.2	28.8	2.2	2.1	6.5	2.8	1.7	3.6	18.0	73.9	104.8	18.5	60.7
	l	36.2	35.6	29.5	2.2	2.2	6.5	2.8	1.8	3.6	19.0	74.1	100.0	18.2	64.3
273	r	36.2	35.9	28.5	2.0	2.0	6.1	2.8	1.7	3.7	27.0	74.9	100.0	17.0	60.7
312	r	37.2	36.7	28.8	2.2	2.0	6.5	2.9	1.7	4.1	31.0	—	110.0	17.7	58.6
327	r	38.5	38.1	31.3	2.1	2.1	6.8	2.8	1.8	4.0	41.0	—	100.0	17.7	64.3
330		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	39.5	38.8	31.6	2.5	2.2	7.1	2.8	1.9	4.0	20.0	—	113.7	18.5	67.9
331	r	38.0	37.5	30.3	2.2	2.1	6.9	2.6	2.0	3.8	18.5	—	104.8	18.4	76.9
333	r	37.3	37.1	29.7	2.5	2.1	7.1	2.9	1.9	4.2	27.0	73.8	119.0	19.1	65.5
343	r	36.8	36.6	29.4	2.1	2.2	6.6	3.0	1.8	—	29.0	—	95.5	18.0	60.0
344	r	36.5	36.1	29.7	2.3	2.2	7.0	2.8	1.9	3.9	29.0	—	104.5	19.4	67.9
351		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	37.3	35.8	29.7	2.3	2.1	6.7	2.7	1.9	4.0	25.0	—	104.8	18.7	70.4
358	r	38.7	38.4	30.4	2.4	2.3	7.5	2.6	2.3	4.1	25.0	—	104.3	19.5	88.5
365		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	36.2	36.0	28.8	2.1	2.0	6.3	3.0	1.8	3.9	24.0	—	105.0	17.5	60.0
464	r	37.9	37.3	29.1	2.1	2.1	6.6	2.7	1.8	3.9	27.0	—	100.0	17.7	66.7
465		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	37.8	37.2	30.0	2.2	2.2	6.3	2.5	2.0	3.7	16.0	—	100.0	16.9	80.0
493	r	39.7	39.4	32.6	2.4	2.2	7.3	2.7	2.2	4.1	22.0	—	109.1	18.5	81.5

Catalogue Number	Side	Maximum Length	Oblique Length	Shaft Length	Antero-posterior Diameter	Transverse Diameter	Circumference	Upper Transverse Diameter	Upper Antero-posterior Diameter	Maximum Vertical Diameter of Caput	Angle of Torsion	Femoro-Humeral Index	Pilastric Index	Caliber Index	Index of Platymeria
PAUCARCANCHA															
498	r	39.4	39.2	3.16	2.3	2.2	7.0	3.0	1.9	3.7	26.0	——	104.5	17.8	63.3
499	r	39.0	38.6	32.0	2.5	2.2	7.2	2.8	1.9	3.9	33.0	——	113.7	18.6	67.9
500	r	38.0	38.0	31.3	2.7	2.2	7.6	2.9	2.0	4.2	22.0	——	122.7	20.0	68.9
524	r	——	——	——	——	——	——	——	——	——	——	——	——	——	——
	l	32.8	32.3	26.2	2.0	2.1	6.3	2.7	1.8	3.5	19.0	——	95.2	19.5	66.7
525	l	36.2	36.0	29.1	2.5	2.2	7.2	2.8	1.9	3.9	24.0	——	113.7	20.0	67.9
526	r	——	——	——	——	——	——	——	——	——	——	——	——	——	——
	l	35.9	35.4	——	2.2	2.1	6.6	2.7	1.8	3.9	18.0	——	104.8	18.9	66.7
527	l	37.6	36.9	30.4	2.2	2.3	7.0	2.7	2.0	3.7	16.0	——	95.6	18.9	74.1
528	l	38.7	38.3	32.2	2.5	2.5	7.6	3.0	2.1	3.9	15.0	——	100.0	19.8	70.0
529	l	37.2	36.4	30.0	2.3	2.3	7.0	2.7	1.8	3.6	14.0	——	100.0	19.2	66.7
531	l	38.0	37.7	29.1	2.3	2.3	7.1	2.8	2.0	4.0	13.0	——	100.0	18.8	71.4
532	l	37.0	36.4	29.7	2.3	2.4	7.1	2.9	1.8	3.9	28.0	——	95.8	19.5	62.1
533	l	36.1	35.2	28.4	2.2	1.9	6.3	2.5	1.9	3.6	20.0	——	115.8	17.9	76.0
534		——	——	——	——	——	——	——	——	——	——	——	——	——	——
	l	39.3	38.9	31.6	2.2	2.3	7.1	3.0	1.8	3.7	22.0	——	95.6	18.2	60.0
535	l	35.3	34.7	27.8	2.5	2.2	7.2	2.6	2.0	3.6	20.0	——	113.7	20.7	76.9
536	l	38.0	37.3	30.0	2.2	2.0	6.4	2.7	1.9	3.9	22.0	——	110.0	17.1	70.4
537	l	36.6	35.9	29.1	2.1	2.2	6.6	3.0	1.9	3.7	25.0	——	95.5	18.7	63.3
538	l	39.0	38.0	31.0	2.4	2.2	7.2	2.8	1.9	3.8	18.0	——	109.1	18.9	67.9
539	l	37.9	37.4	30.3	2.3	2.3	7.2	2.9	2.0	3.9	5.0	——	100.0	19.2	68.9
541	r	——	——	——	——	——	——	——	——	——	——	——	——	——	——
	l	37.3	36.8	29.4	2.1	2.2	6.8	3.3	1.9	3.7	31.0	——	95.5	18.5	57.9
542	l	38.9	38.2	31.0	2.3	2.1	6.7	2.6	1.9	3.9	21.0	——	104.8	17.5	73.1

Catalogue Number	Side	Maximum Length	Oblique Length	Shaft Length	Antero-posterior Diameter	Transverse Diameter	Circumference	Upper Transverse Diameter	Upper Antero-posterior Diameter	Maximum Vertical Diameter of Caput	Angle of Torsion	Femoro-Humeral Index	Pilastric Index	Caliber Index	Index of Platymeria
PAUCARCANCHA															
543	r	34.2	33.8	27.8	2.0	2.3	6.6	2.8	1.8	3.5	24.0	—	86.9	19.2	64.3
544	r	36.9	36.5	30.0	2.2	2.1	6.7	2.8	2.0	3.7	29.0	—	104.8	18.4	71.4
545	r	31.8	31.4	25.0	1.9	1.8	5.8	2.7	1.5	3.5	19.0	—	105.5	18.5	55.5
546	r	39.4	38.8	31.6	2.2	2.1	6.9	2.7	1.8	3.9	28.0	—	104.8	17.8	66.7
550	r	34.8	34.1	27.5	2.5	2.1	7.3	2.7	2.0	3.7	22.0	—	119.0	21.4	74.1
551	r	35.7	35.0	28.5	2.1	1.8	5.9	2.6	1.8	3.6	34.0	—	116.7	16.9	69.2
553	r	36.3	35.9	29.4	2.2	2.1	6.7	3.0	1.7	3.9	45.0	—	104.8	18.7	56.7
554	r	36.9	36.1	29.8	2.3	2.3	7.3	2.7	1.9	3.7	4.0	—	100.0	20.2	70.4
♂479															
	l	39.3	38.9	32.3	2.7	2.5	8.3	2.9	2.1	3.9	00.0	—	108.0	21.4	72.4
507	r	38.7	38.6	31.1	2.3	2.2	7.0	2.8	1.8	4.1	38.0	—	104.5	18.1	64.3
508	r	39.1	38.6	31.3	2.6	2.4	7.6	3.0	2.0	4.0	26.0	—	108.3	19.7	66.7
540															
	l	39.4	38.8	32.0	2.4	2.5	7.6	2.9	1.9	3.8	9.0	—	96.0	19.6	65.5
547	r	38.0	37.6	31.3	2.4	2.5	7.6	3.0	2.1	3.9	20.0	—	96.0	20.2	70.0
548	r	37.1	36.9	31.0	2.1	2.2	6.8	2.8	1.9	3.9	31.0	—	95.5	18.4	67.9
549	r	37.2	36.8	29.7	2.2	2.2	6.7	2.7	2.0	3.8	18.0	—	100.0	18.6	74.1
552	r	37.5	37.0	30.3	2.2	2.2	6.8	2.9	2.0	3.9	22.0	—	100.0	18.4	68.9
555	r	39.6	39.3	32.0	2.2	2.4	7.1	3.0	1.8	3.8	5.0	—	91.7	18.1	60.0
556	r	38.7	38.3	31.3	2.3	2.4	7.2	2.9	2.0	3.9	30.0	—	95.8	18.8	68.9
PATALLACTA															
♂709	r	42.5	42.0	33.5	2.7	2.5	7.8	3.4	2.1	4.9	26.0	—	108.0	18.6	61.8
	l	42.0	41.5	33.5	2.7	2.6	7.9	3.5	2.1	5.1	24.0	—	103.9	19.0	60.0

Catalogue Number	Side	Maximum Length	Oblique Length	Shaft Length	Antero-posterior Diameter	Transverse Diameter	Circumference	Upper Transverse Diameter	Upper Antero-posterior Diam.	Maximum Vertical Diameter of Caput	Angle of Torsion	Femoro-Humeral Index	Pilastric Index	Caliber Index	Index of Platymeria
PATALLACTA															
730		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	39.4	39.0	31.6	2.8	2.4	8.0	3.0	2.0	4.3	18.0	—	116.7	20.5	66.7
731		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	41.0	40.6	32.2	2.5	2.5	7.9	3.1	2.0	4.4	30.0	—	100.0	19.4	64.5
733	r	39.0	38.8	31.0	2.6	2.4	7.5	3.2	2.0	4.6	21.0	—	108.3	19.3	62.5
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
736	r	38.4	38.0	31.3	2.6	2.4	7.8	3.0	2.2	4.0	16.0	—	108.3	20.5	74.0
	l	38.5	38.0	31.0	2.5	2.3	7.5	3.0	2.1	4.0	24.0	—	108.7	19.7	70.0
992	r	40.7	40.1	32.7	2.5	2.5	7.8	3.2	2.0	4.5	21.0	—	100.0	19.4	62.5
	l	40.8	40.4	33.2	2.5	2.5	7.9	3.2	2.0	4.5	19.0	—	100.0	19.5	62.5
993	r	37.6	37.2	29.1	2.5	2.3	7.5	2.9	2.2	4.1	15.0	—	108.7	20.1	75.9
	l	37.7	37.2	29.4	2.5	2.3	7.5	2.8	2.1	4.0	15.0	—	108.7	20.1	75.0
1029		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	39.8	39.5	32.0	2.5	2.4	7.8	3.3	2.1	4.6	25.0	—	104.2	19.7	63.6
1032		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	38.6	38.0	31.0	2.5	2.4	7.7	2.9	2.1	4.0	9.0	—	104.2	20.3	72.4
1034		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	43.2	43.1	35.3	2.7	2.4	7.8	3.2	2.1	4.3	23.0	—	112.5	18.1	65.6
1049	r	41.1	40.5	32.9	2.6	2.5	7.8	3.4	2.1	4.5	22.0	—	104.0	19.3	61.8
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
1050	r	40.0	39.9	32.3	2.3	2.3	7.2	3.0	2.1	4.4	22.0	—	100.0	18.1	70.0
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
1051	r	40.7	40.5	33.4	2.5	2.4	7.4	3.2	1.9	4.5	16.0	—	104.2	18.3	59.4
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
1052		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	42.0	41.4	33.5	2.7	2.7	8.3	3.8	2.1	4.6	24.0	—	100.0	20.1	55.3
♀732r		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	36.1	35.9	28.8	2.3	2.3	6.9	2.9	1.8	3.9	30.0	—	100.0	19.2	62.1
996	r	36.9	36.6	29.7	2.3	2.2	7.0	2.9	2.1	4.0	33.0	—	104.5	19.1	72.4
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
997	r	38.8	38.2	30.7	2.2	2.1	6.6	2.5	2.0	3.6	30.0	—	104.8	17.3	80.0
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
998	r	37.6	37.4	31.0	2.0	2.1	6.5	2.7	1.7	3.7	41.0	—	95.2	17.4	62.9
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
999	r	38.0	37.4	30.7	2.0	2.3	6.6	2.9	1.8	3.9	40.0	—	86.9	17.6	62.1
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
1000		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	38.9	38.3	31.0	2.1	2.4	6.9	2.9	1.8	3.9	16.0	—	87.5	18.0	62.1
1001		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	38.1	37.8	31.3	2.1	2.3	6.7	2.7	1.8	3.7	14.0	—	91.3	17.7	66.7

Catalogue Number	Side	Maximum Length	Oblique Length	Shaft Length	Antero-posterior Diameter	Transverse Diameter	Circumference	Upper Transverse Diameter	Upper Antero-posterior Diam.	Maximum Vertical Diameter of Caput	Angle of Torsion	Femoro-Humeral Index	Pilastric Index	Caliber Index	Index of Platymeria
PATALLACTA															
1002		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	39.1	38.6	31.3	2.3	2.0	6.7	2.5	2.0	3.7	24.0	—	115.0	17.3	80.0
1037	r	35.8	35.3	28.4	2.2	2.2	6.9	2.8	1.8	3.7	30.0	—	100.0	19.3	64.3
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
1038	r	37.7	37.3	30.0	2.3	2.4	7.2	2.9	2.0	3.8	19.0	—	95.8	19.3	68.9
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
1039	r	34.3	32.9	27.2	1.9	2.0	6.2	2.5	1.7	3.7	23.0	—	95.0	18.3	68.0
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
1041		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	32.4	32.3	26.2	2.1	2.0	6.4	2.8	1.9	3.3	17.0	—	105.0	19.8	67.9
1054		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	38.3	38.0	31.3	2.3	2.3	7.2	2.7	2.0	3.8	19.0	—	100.0	18.8	74.1
TORONTOY															
♂775	r	38.5	38.0	—	2.4	2.2	7.1	2.9	1.9	4.5	29.0	72.1	104.5	18.7	65.5
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
779	r	41.7	41.4	33.5	2.6	2.4	7.8	2.9	2.2	4.4	2.0	—	108.3	18.8	75.9
	l	41.9	41.5	33.5	2.4	2.4	7.8	3.0	2.1	4.4	2.0	—	100.0	18.8	70.0
780	r	43.8	42.9	34.5	2.5	2.4	7.5	2.9	2.1	4.6	32.0	—	104.2	17.5	72.4
	l	43.8	43.3	34.3	2.5	2.4	7.5	2.9	2.0	4.6	32.0	—	104.2	17.3	68.9
781	r	40.5	40.0	32.0	2.5	2.3	7.5	3.1	2.0	4.3	23.0	—	108.7	18.7	64.5
	l	40.5	40.2	32.3	2.5	2.4	7.7	3.1	2.1	4.3	22.0	—	104.2	19.1	67.7
786a	r	36.5	36.0	28.8	2.5	2.6	8.0	3.1	2.0	4.6	25.0	76.1	96.2	22.2	64.5
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
787	r	39.1	38.8	31.3	2.2	2.0	6.7	2.8	1.7	4.0	32.0	—	110.0	17.3	60.7
	l	39.4	39.2	31.2	2.4	2.1	6.9	2.9	1.9	4.0	20.0	—	114.3	17.6	65.5
788	r	38.0	37.8	30.6	2.6	2.3	7.7	2.8	2.0	4.2	24.0	77.5	113.0	20.4	71.4
	l	38.9	38.4	31.0	2.3	2.3	7.1	2.8	1.9	3.9	23.0	—	100.0	18.5	67.9
789		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	42.4	42.3	34.2	2.7	2.4	7.9	3.2	2.1	4.7	22.0	—	112.5	18.7	65.6
790	r	37.2	37.2	29.4	2.3	2.1	7.0	2.6	1.9	4.5	31.0	75.3	109.5	18.8	73.1
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
845	r	39.7	39.4	31.4	2.3	2.3	7.3	3.3	1.8	4.3	25.0	—	100.0	18.5	54.5
	l	39.8	39.5	31.6	2.5	2.5	7.8	3.4	2.0	4.2	17.0	—	100.0	19.7	58.8
♀778	r	39.7	39.0	31.3	2.1	2.0	6.4	2.7	1.7	4.0	23.0	—	105.0	16.4	62.9
	l	39.4	38.9	31.3	2.0	2.1	6.4	2.8	1.7	3.9	23.0	—	95.2	16.4	60.7
782	r	38.2	37.8	31.3	2.4	2.6	7.8	3.1	2.2	4.1	22.0	—	92.3	20.6	70.9
	l	38.8	38.5	31.3	2.4	2.5	7.7	3.2	2.1	4.1	24.0	—	96.0	20.0	65.6

Catalogue Number	Side	Maximum Length	Oblique Length	Shaft Length	Antero-posterior Diameter	Transverse Diameter	Circumference	Upper Transverse Diameter	Upper Antero-posterior Diam.	Maximum Vertical Diameter of Caput	Angle of Torsion	Femoro-Humeral Index	Pilastric Index	Caliber Index	Index of Platymeria
PATALLACTA															
831	r	37.4	37.0	30.3	2.3	2.1	7.0	2.6	1.8	3.8	25.0	—	109.5	18.9	69.2
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
835	r	38.3	38.1	30.7	2.3	2.3	7.2	2.8	2.0	3.9	24.0	—	100.0	18.9	71.4
		—	—	—	—	—	—	—	—	—	—	—	—	—	—
839	r	36.9	36.4	30.0	1.9	1.9	6.1	2.6	1.7	3.6	27.0	—	100.0	16.8	65.4
	l	36.7	36.2	29.7	2.0	2.0	6.3	2.5	1.7	—	15.0	—	100.0	17.4	68.0
843		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	38.7	38.4	31.3	2.4	2.1	7.0	2.8	1.8	3.9	26.0	—	114.3	18.2	64.3
HUATA															
♂902		—	—	—	—	—	—	—	—	—	—	—	—	—	—
	l	42.0	41.8	33.2	2.6	2.5	7.8	3.2	2.1	4.4	14.0	—	104.0	18.7	65.6
♀910	r	39.6	38.7	31.6	2.5	2.2	7.6	2.9	2.2	4.4	24.0	72.9	113.6	19.6	75.9
	l	40.0	39.0	31.6	2.5	2.2	7.5	2.8	2.1	4.3	19.0	—	113.6	19.2	75.0
HUISPANG															
♂921	r	39.0	38.7	30.3	2.5	2.3	7.5	2.9	2.2	4.2	34.0	72.9	108.7	19.4	75.9
	l	39.1	38.7	30.6	2.5	2.4	7.6	2.8	2.2	4.2	33.0	71.1	104.2	19.6	78.6
HUAROCONDO															
♂923	r	42.9	42.3	34.5	2.8	2.5	8.1	3.5	2.2	4.5	22.0	74.5	112.0	19.1	62.9
	l	42.7	42.4	34.2	2.7	2.5	7.9	3.5	2.3	4.6	24.0	71.5	108.0	18.6	65.7

TABLE XII—TIBIA

Catalogue Number	Side	Maximum Length	Condylo-Astragaloid Length	Transverse Diameter	Antero-posterior Diameter	Index of Platycnemia
PAUCARCANCHA						
♂123	r	32.0	30.8	1.9	2.7	70.4
	l	32.1	30.9	1.7	2.7	62.9
160	r	30.3	31.5	1.9	2.8	67.9
	l	32.7	31.5	1.9	2.9	65.5
268		—	—	—	—	—
	l	31.0	29.7	2.0	3.0	66.7
274	r	32.3	30.8	1.7	2.9	55.2
	l	32.3	30.7	2.0	2.8	71.4
277		—	—	—	—	—
	l	33.2	31.8	2.0	2.7	77.8
289a		—	—	—	—	—
	l	32.2	30.8	1.9	2.9	65.5
290	r	34.0	32.5	2.0	3.0	66.7
		—	—	—	—	—
294	r	30.0	28.7	1.9	2.3	82.6
		—	—	—	—	—
392	r	33.5	32.0	2.1	2.6	80.8
		—	—	—	—	—
332	r	30.7	29.8	2.1	2.9	72.4
	l	30.5	29.6	2.0	3.0	66.7
334	r	33.6	32.5	1.9	2.9	75.5
		—	—	—	—	—
342		—	—	—	—	—
	l	32.7	31.3	1.9	2.8	67.9
345	r	33.5	32.2	2.1	2.9	72.4
		—	—	—	—	—
346	r	31.1	29.8	1.6	2.5	64.0
		—	—	—	—	—
353		—	—	—	—	—
	l	34.4	32.8	1.7	2.7	62.9
354		—	—	—	—	—
	l	34.3	32.8	1.9	2.9	65.5
355	r	32.1	30.8	1.8	2.5	72.0
		—	—	—	—	—
460	r	26.6	25.2	1.8	2.3	78.3
		—	—	—	—	—
467	r	30.7	29.6	1.8	2.7	66.7
	l	30.7	29.6	1.8	2.6	69.2
468	r	31.1	29.8	1.9	2.8	67.9
	l	31.1	29.7	1.9	2.8	67.9
514		—	—	—	—	—
	l	36.6	35.3	2.1	3.2	65.6
515		—	—	—	—	—
	l	33.3	31.7	1.9	2.9	65.5
516		—	—	—	—	—
	l	33.6	31.8	1.9	2.7	70.4
517	r	36.1	35.0	2.1	3.2	65.6
		—	—	—	—	—
518	r	34.7	33.4	2.1	2.9	72.4
		—	—	—	—	—
519	r	33.3	32.2	1.7	2.8	60.7
		—	—	—	—	—
557		—	—	—	—	—
	l	32.4	31.1	—	—	—
♀39	r	29.4	28.4	1.7	2.4	70.8
	l	29.3	28.2	1.7	2.3	73.9
159		—	—	—	—	—
	l	30.5	29.1	1.8	2.5	72.0
312	r	29.6	28.4	1.8	2.5	72.0
		—	—	—	—	—
327	r	31.5	30.2	1.9	2.3	82.6
		—	—	—	—	—
330		—	—	—	—	—
	l	31.6	30.4	1.8	2.6	69.2
331	r	29.3	27.6	1.6	2.3	69.6
		—	—	—	—	—
333	r	31.5	30.3	1.6	2.6	61.5
		—	—	—	—	—
343	r	28.6	27.4	1.7	2.3	7.39
		—	—	—	—	—
351		—	—	—	—	—
	l	29.2	27.8	1.9	2.5	76.0
361	r	26.3	25.4	1.4	1.9	73.7
		—	—	—	—	—
365		—	—	—	—	—
	l	30.9	29.8	1.6	2.4	66.7
464	r	30.6	29.3	1.7	2.3	73.9
		—	—	—	—	—
465		—	—	—	—	—
	l	29.4	28.2	1.5	2.3	65.2

Catalogue Number	Side	Maximum Length	Condylo-Astragaloid Length	Transverse Diameter	Antero-posterior Diameter	Index of Platycnemia
♂♀						
328		—	—	—	—	—
	l	31.1	29.5	1.7	2.6	65.4
352		—	—	—	—	—
	l	28.8	27.5	1.7	2.4	70.8

PATALLACTA

Catalogue Number	Side	Maximum Length	Condylo-Astragaloid Length	Transverse Diameter	Antero-posterior Diameter	Index of Platycnemia
♂690		—	—	—	—	—
	l	31.7	30.8	—	—	—
709		—	—	—	—	—
	l	33.4	32.3	1.9	3.0	63.3
737	r	33.9	32.7	1.9	2.8	67.9
		—	—	—	—	—
738	r	32.5	31.4	2.1	2.8	75.0
		—	—	—	—	—
♂♀						
739		—	—	—	—	—
	l	29.5	28.5	—	—	—

TORONTOY

Catalogue Number	Side	Maximum Length	Condylo-Astragaloid Length	Transverse Diameter	Antero-posterior Diameter	Index of Platycnemia
♂779	r	33.5	32.1	2.0	2.6	76.9
	l	33.9	32.3	1.9	2.4	79.2
780	r	34.5	33.1	1.9	2.8	67.9
	l	34.4	33.2	1.8	3.2	56.2
781	r	32.6	31.5	2.7	2.8	60.7
	l	32.6	31.5	1.6	3.0	53.3
786a	r	30.3	29.0	2.1	2.8	75.0
		—	—	—	—	—
787	r	33.6	31.6	1.5	2.6	50.0
		—	—	—	—	—
788		—	—	—	—	—
	l	31.5	30.3	1.7	2.5	68.0
790	r	31.7	30.6	1.7	2.8	60.7
		—	—	—	—	—

Catalogue Number	Side	Maximum Length	Condylo-Astragaloid Length	Transverse Diameter	Antero-posterior Diameter	Index of Platycnemia
822	r	31.6	30.4	1.9	2.8	67.9
		—	—	—	—	—
838	r	30.3	29.0	2.0	2.5	80.0
		—	—	—	—	—
845	r	31.5	30.2	1.7	2.4	70.8
	l	31.5	30.3	1.8	2.4	75.0
♀778	r	31.7	30.6	1.6	2.3	69.6
	l	31.6	30.5	1.6	2.4	66.7
782		—	—	—	—	—
	l	30.4	29.3	1.9	2.5	76.0
831		—	—	—	—	—
	l	27.3	25.7	1.7	2.1	80.9
835	r	31.5	30.4	1.7	2.6	65.4
		—	—	—	—	—
839		—	—	—	—	—
	l	29.8	28.6	1.4	2.2	63.6
843	r	31.4	30.1	1.8	2.5	72.0
	l	31.7	30.3	1.9	2.6	73.1

HUATA

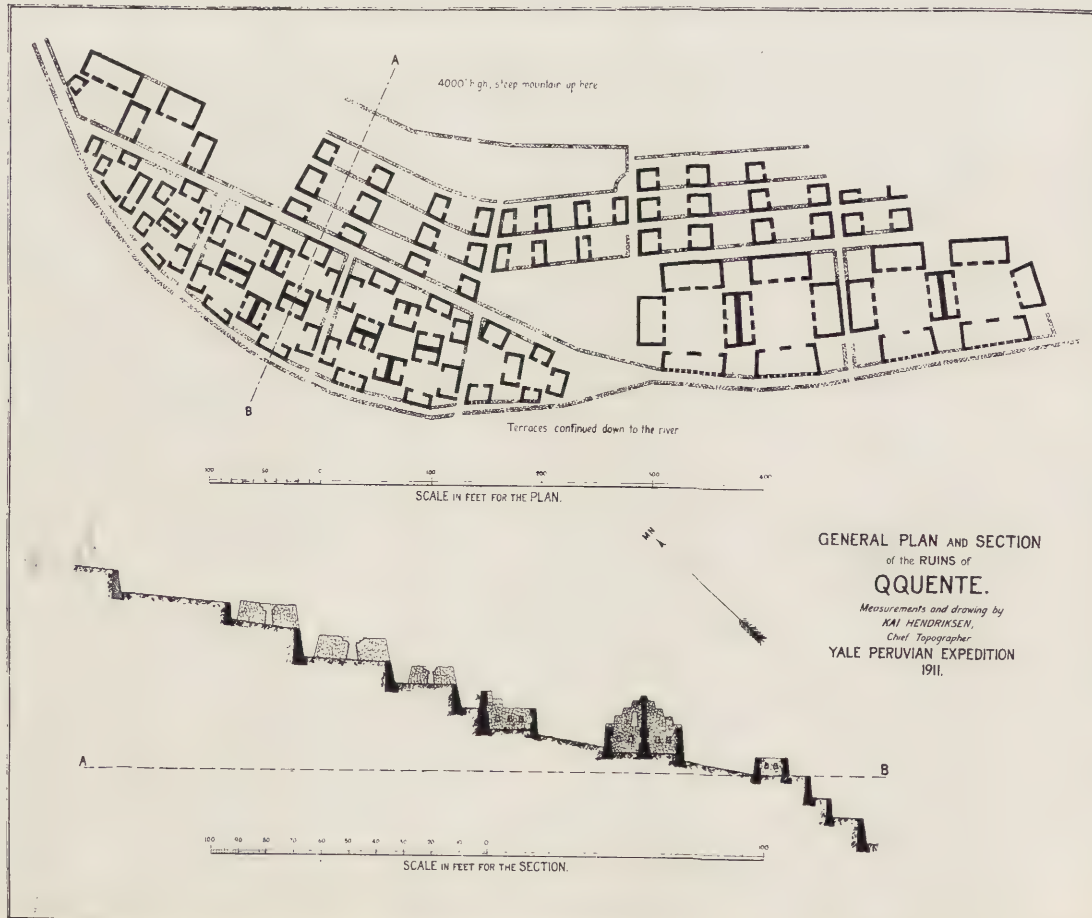
Catalogue Number	Side	Maximum Length	Condylo-Astragaloid Length	Transverse Diameter	Antero-posterior Diameter	Index of Platycnemia
♂902		—	—	—	—	—
	l	33.3	32.3	1.7	2.8	60.7
♀910	r	32.0	30.7	—	—	—
	l	31.8	30.7	1.9	2.6	73.1

HUISPANG

Catalogue Number	Side	Maximum Length	Condylo-Astragaloid Length	Transverse Diameter	Antero-posterior Diameter	Index of Platycnemia
♂921	r	32.1	30.7	—	—	—
	l	32.0	30.5	1.9	3.0	63.3

HUAROCONDO

Catalogue Number	Side	Maximum Length	Condylo-Astragaloid Length	Transverse Diameter	Antero-posterior Diameter	Index of Platycnemia
♂923	r	34.1	32.8	2.0	2.9	68.6
	l	33.5	32.3	1.9	3.0	63.3



General Plan and Section of the Ruins of Qquente. Measurements and drawing by Kai Hendriksen, Chief Topographer, Yale Peruvian Expedition, 1911.

Plate No. I—*Upper*, Pampaccahuana valley, with Ruins of Paucarcancha. General view. Photo by Hiram Bingham. *Lower*, Main entrance to the ruins of Paucarcancha. Photo. by Hiram Bingham.

PLATE No. II—*Upper*, Ruins of Paucarcancha. Details of construction. Gable 47. Photo. by Hiram Bingham. *Lower*, Ruins of Paucarcancha. View from Gable 47. Photo. by Hiram Bingham.

PLATE No. III—Paucarcancha. Mummy of a male about 20 years old. The cranium had been trephined, but did not heal (Cat. no. 75). See also Pl. XXII.

Plate No. IV—*Upper*, Paucarcancha. Mummy of a child about 9 or 10 years old (Cat. no. 124). *Lower*, Paucarcancha. House at the northwest corner of Patahuasa, 18 by 20 feet. Three windows on the northwest side. Photo. by E. C. Erdis.

Plate V—*Upper left.* Paucarcancha. Mummy of an adult female (Cat. no. 39). See also Pl. XXXII. Photo. by Hiram Bingham. *Upper right,* Paucarcancha. Grave under house 16–I containing the skeletons of a man, woman and child; only one, that of the female, is visible. Photo. by J. H. J. *Lower left,* Torontoy. Mummy of an adult male with trepanned skull (Cat. no. 790). From a cave above the ruins. Photo. by Hiram Bingham. *Lower right,* Huispang. Gable house on south point. Photo. by E. C. Erdis.

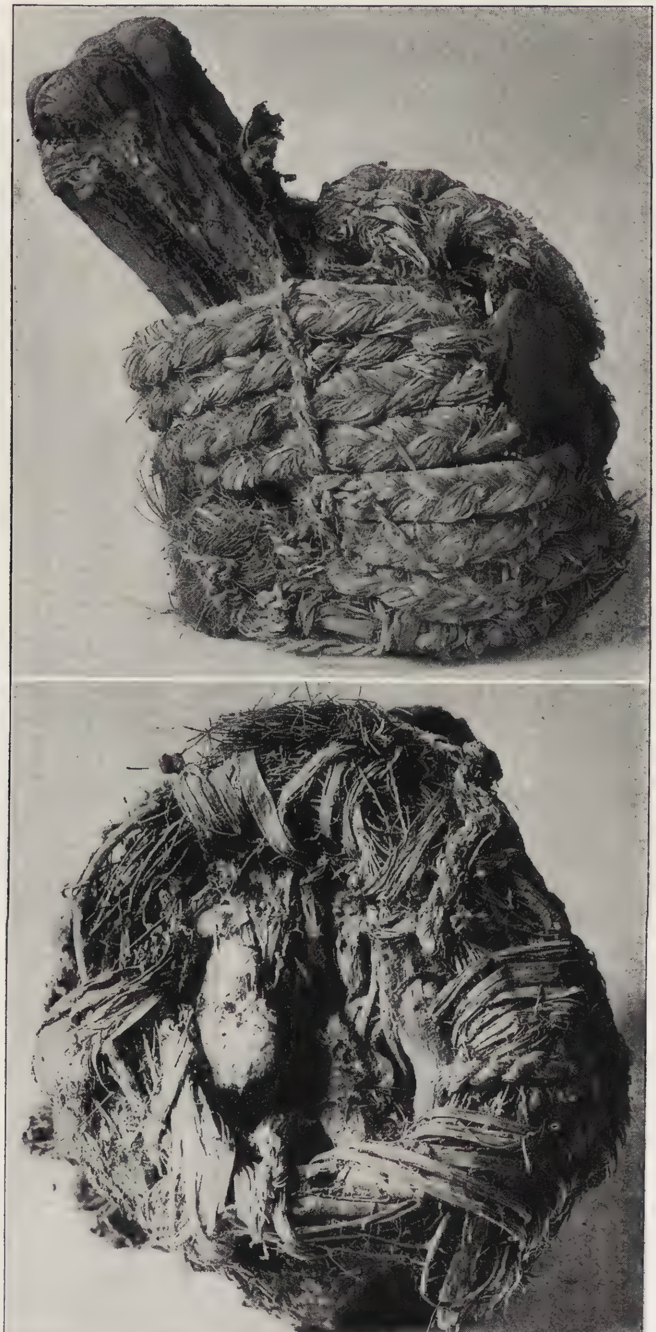


PLATE No. VI—*Upper*, Paucarcancha. Part of a mummy of a male about 21 years old; view of left side (Cat. no. 123). See figs. 45, 70 and 71. *Lower*, Basal view of the same showing the circular seat of withes; also the coccyx at the base and the heels pressed against the pubic arch in the center.

PLATE No. VII—*Upper*, Patallacta. Looking toward the Urubamba valley from a point above the ruins. Photo. by H. L. Tucker. *Lower*, Ruins of Patallacta. Last day of the clearing. Photo. by Yale Peruvian Expedition.

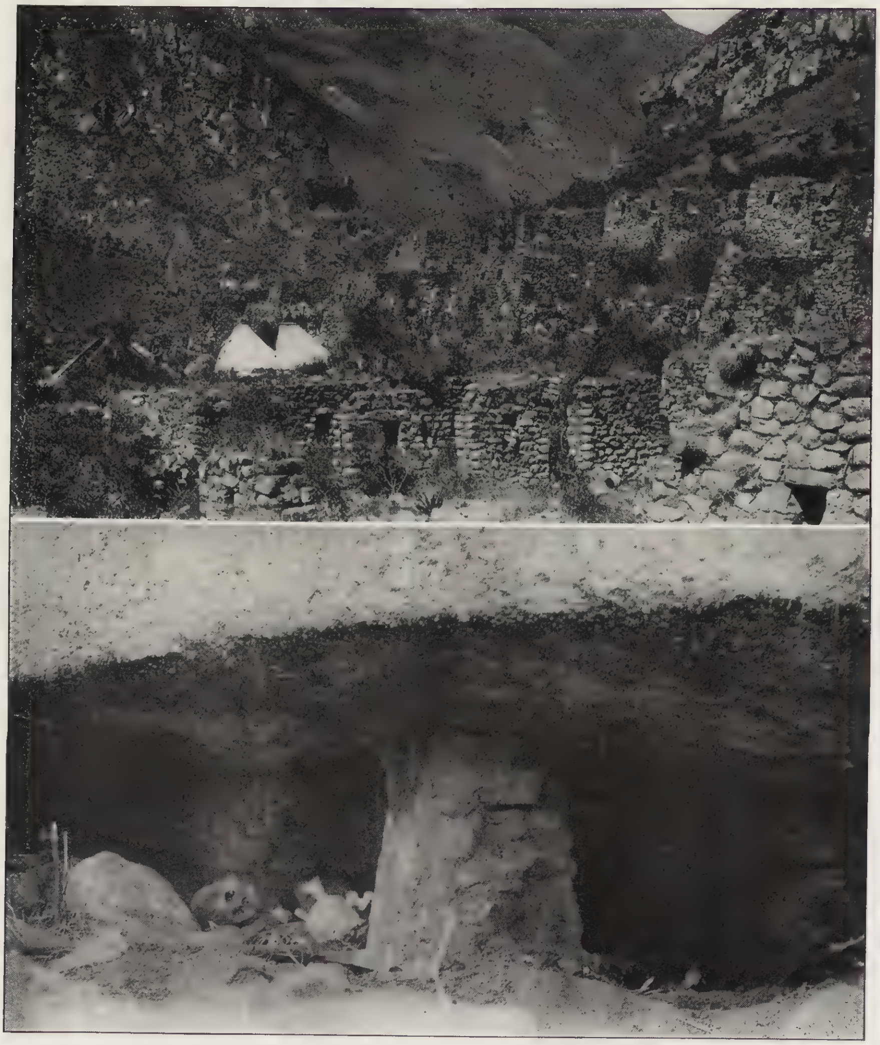


PLATE No. VIII—*Upper*, Ruins of Patallacta. Photo by Hiram Bingham. *Lower*, Patallacta. Cave 66 H and 67 H, separated by an artificial partition. Photo. by J. J. Hasbrouck.

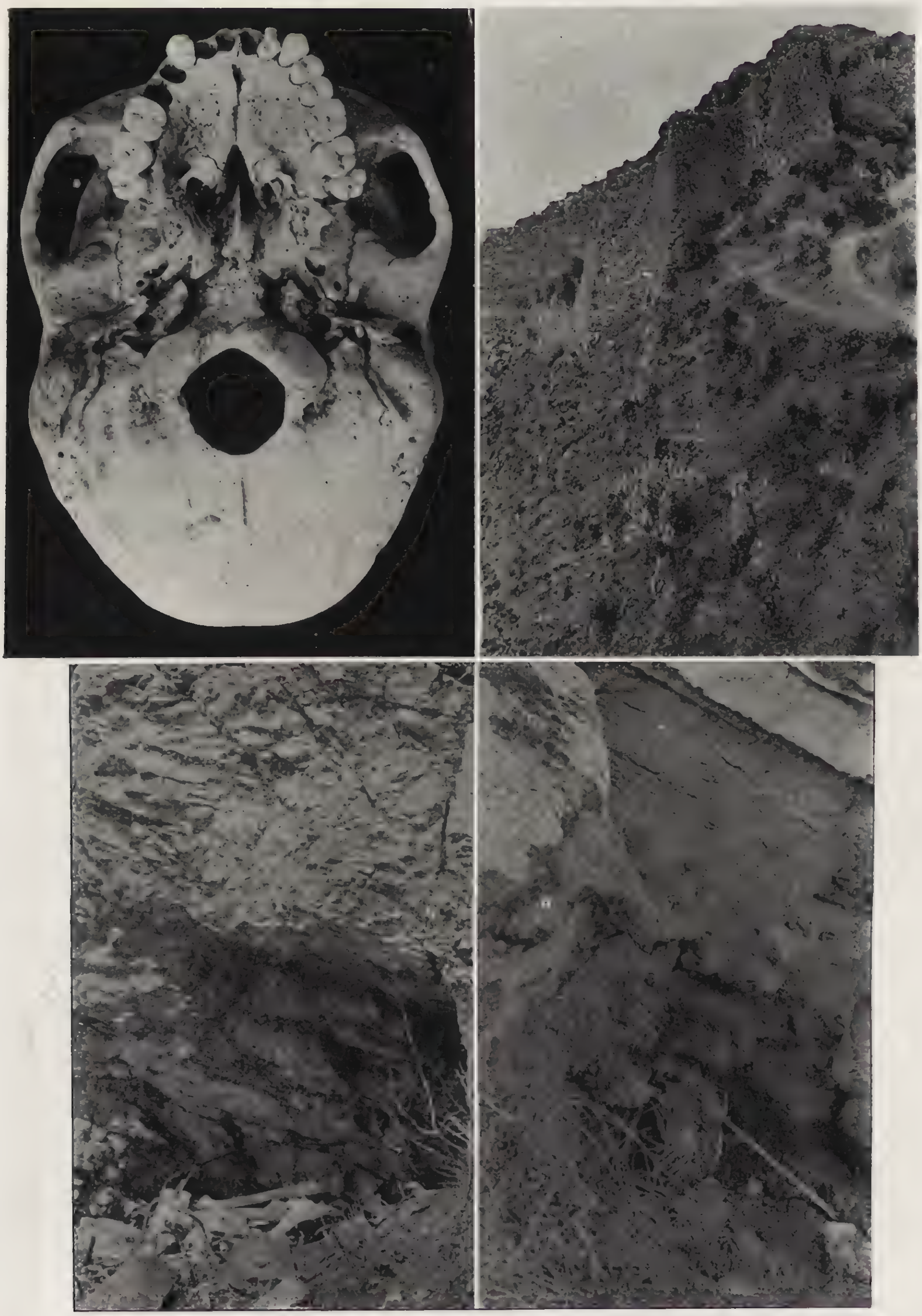
Plate No. IX—*Upper*, Patallacta. Entrance to the chulpa or tomb near the ruins. Photo. by Hiram Bingham. *Lower*, Patallacta. The upper bath or fountain of the row in front of the ruins. Photo. by Hiram Bingham.

PLATE No. X—*Upper*, Patallacta. Burial place near the ruins. Photo. by Hiram Bingham. *Lower*, Patallacta. Cliff tomb back of Qquente and human skeletal remains found in it. Photo. by H. L. Tucker.

PLATE No. XI—*Upper*, Torontoy. Hill ruins and terraces. Photo. by H. L. Tucker.
Lower, Torontoy. Southwest corner of building B. Photo. by H. L. Tucker.

Plate No. XII—*Upper*, Torontoy. Exterior of carved house; splendid masonry. Photo. by J. J. Hasbrouck. *Lower*, Torontoy. Interior of the same house. Photo. by J. J. Hasbrouck.

PLATE XIII—Huispang. Gable house in the center of the town. Photo. by E. C. Erdis.



PL ATE XIV—*Upper left,* Huispang. Cranium of an adult male with cleft palate (Cat. no. 912). *Upper right,* Northwest angles of Huata. Photo. by P. A. .M *thirrgo Lwe,* Huata. Cave no. 11, some 200 feet east of the houses on east point Photo. by Yale Peruvian Expedition. *Lower left,* Skeleton in a cave bythe road one mile below Huarocondo (Cat. no. 923). Photo. by E. C. Erdis.

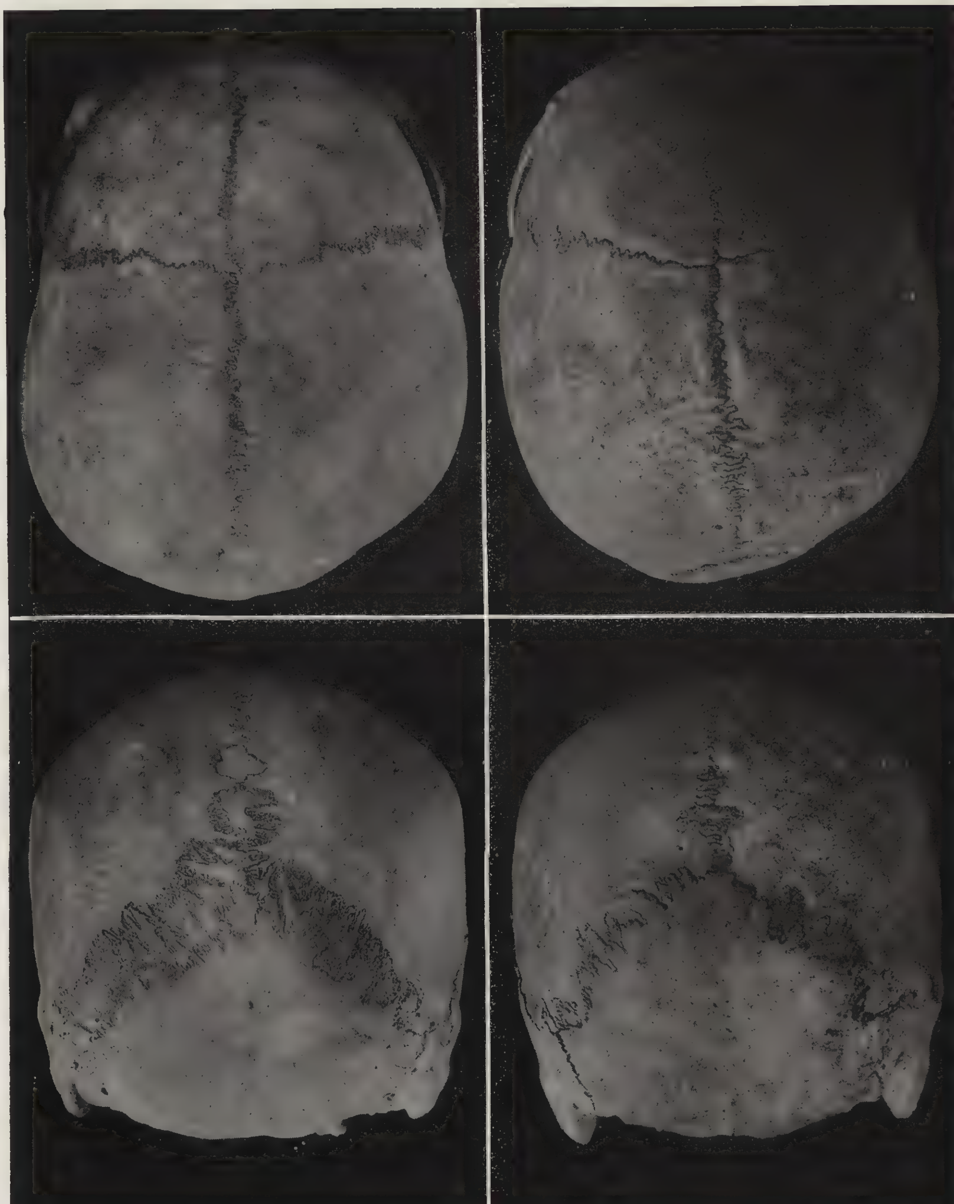


PLATE No. XV—*Upper left*, Huata. Vertical aspect of adult male cranium, the largest in the collection; from cave no. 11 (Cat. no. 880). *Upper right*, Huata. Vertical aspect of adult male cranium from cave no. 11 (Cat. no. 881). *Lower left*, Huata. Posterior aspect of no. 1. *Lower right*, Huata. Posterior aspect of no. 2.

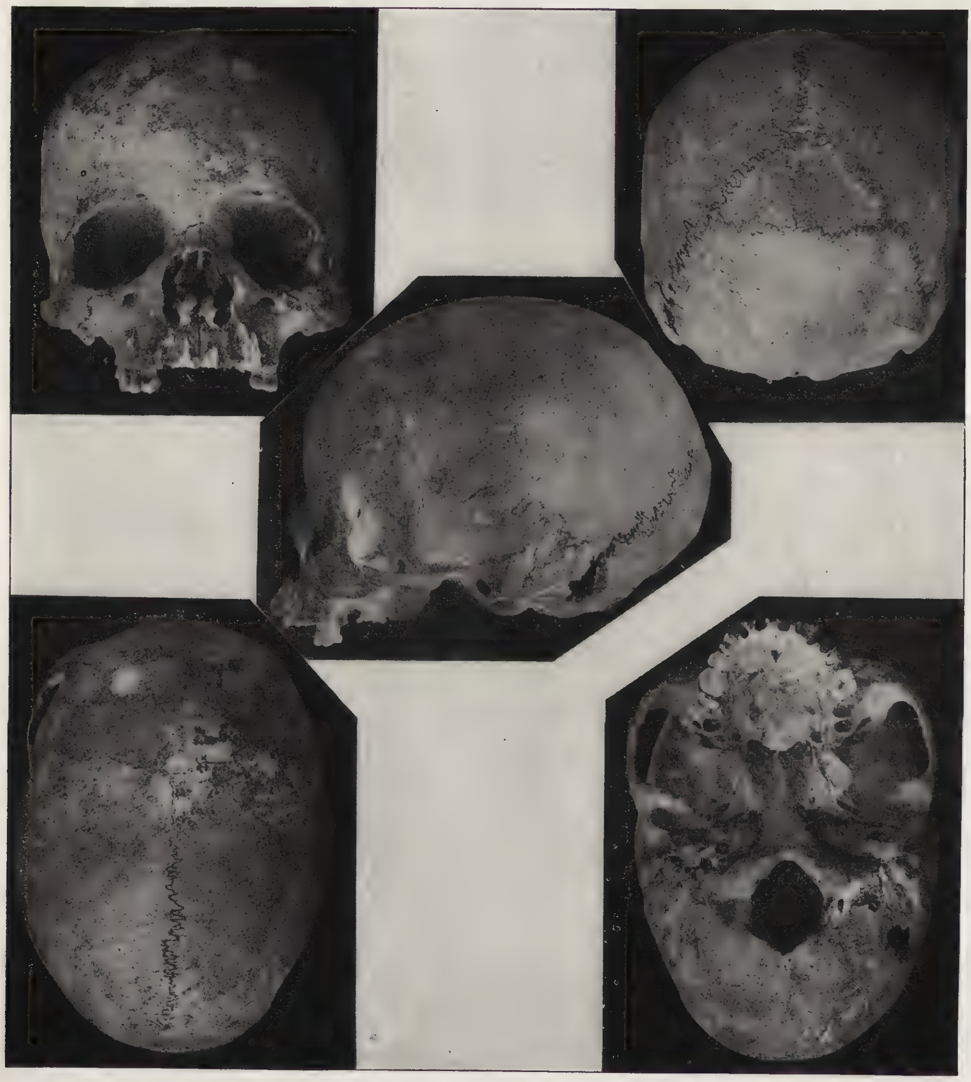


Plate No. XVI—Paucarcancha. Five aspects of the cranium of an adult female (Cat. no. 1). No. 1, frontal aspect; No. 2, posterior aspect; No. 3, lateral aspect; No. 4, vertical aspect; No. 5, basal aspect.

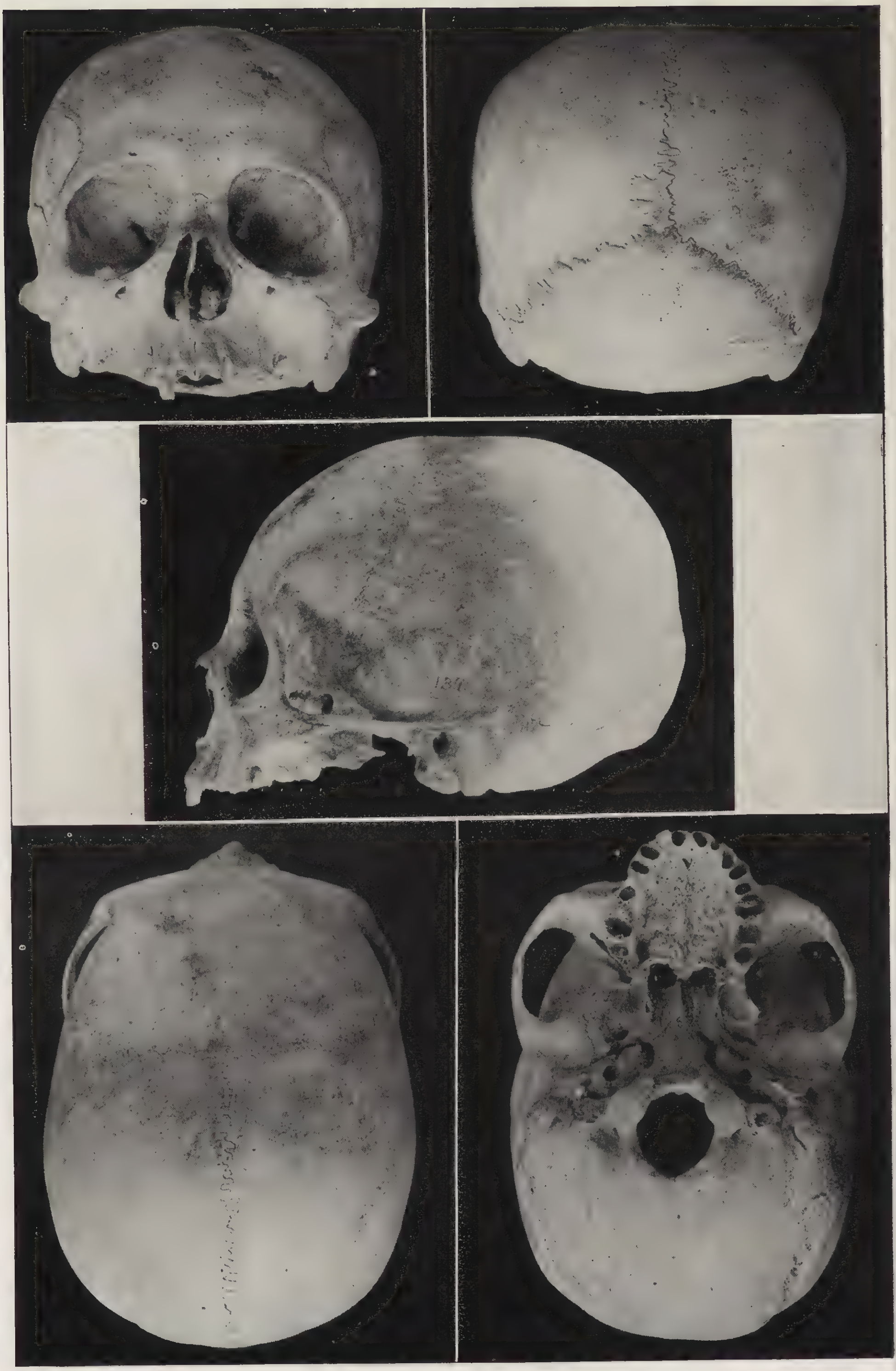


Plate No. XVII—Paucarcanchia. Five aspects of the cranium of an adult female, the smallest in the collection (Cat. no. 137). No. 1, frontal aspect; No. 2, posterior aspect; No. 3, lateral aspect; No. 4, vertical aspect; No. 5, basal aspect.

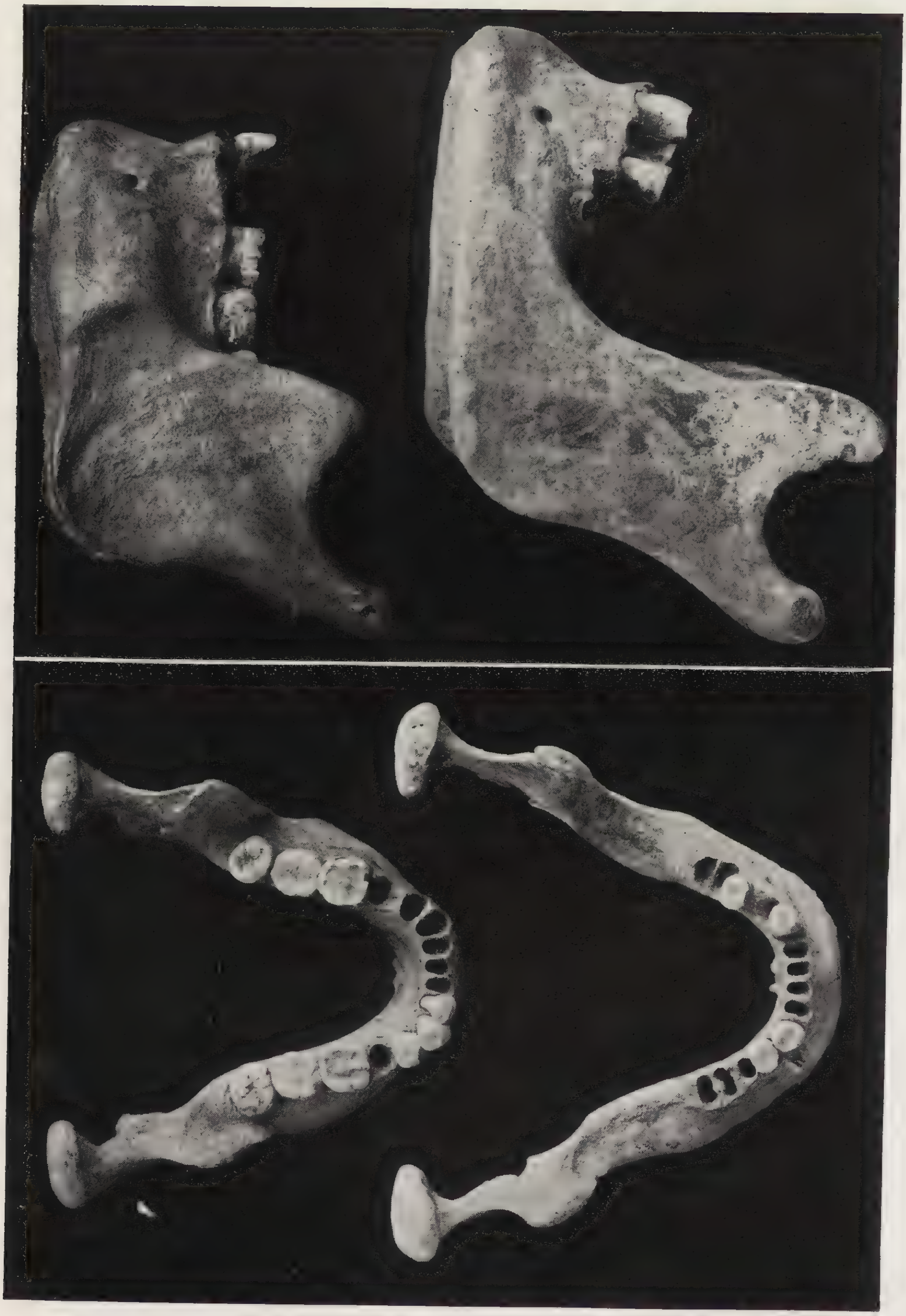


PLATE XVIII—A remarkably small and narrow but robust adult male lower jaw from Paucarcancha. (Cat.no. 194) compared with that of an ordinary adult male from Huarocondo (Cat. no. 923).

PLATE XIX—Paucarcancha. Humerus and radius of a small robust adult male (Cat. no. 299) compared with those of an ordinary adult male from Huarocondo (Cat. no. 923).

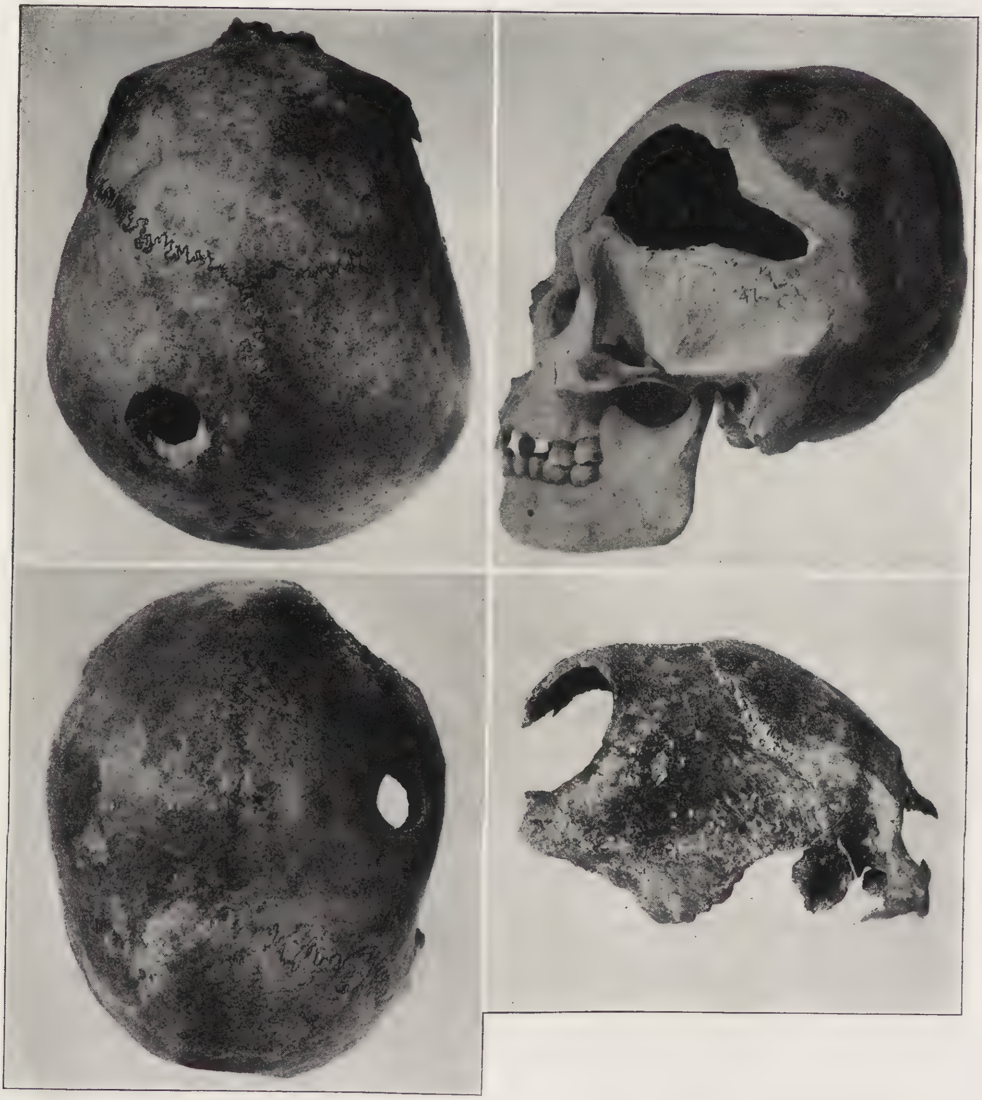


PLATE No. XX—*Left upper*, Paucarcancha. Cranium of an adult female; trephining operation in the left parietal; bone did not heal (Cat. no. 32). *Right upper*, Paucarcancha. Skull of adult male; serious depressed fracture in left temple; broken bone removed by trepanation; margins did not heal (Cat. no. 47). *Left lower*, Paucarcancha. Cranium of an adult female; trepanation in right parietal bone; did not heal (Cat. no. 52). *Right lower*, Paucarcancha. Fragmentary cranium of an adult female; very large opening in the right parietal due to trepanation; bone did not heal (Cat. no. 68).

Plate No. XXI—*Left upper*, Patallacta. Cranium of an adult male with five circular trepanations of which the margins had all healed (Cat. no. 628). Frontal aspect. *Right upper*, Vertical aspect of No. 1. *Left lower*, Huata. Cranium of an adult male with trepanations and depressed fractures, all of which had healed (Cat. no. 877). Frontal aspect. *Right lower*, Upper aspect of No. 3.

PLATE No. XXII—*Left upper*, Paucarcancha. Cranium of adult female; trepanation by scraping or by cauterization on right parietal and frontal (Cat. no. 43). *Right, upper*, Paucarcancha. Cranium of adult male; pit over left orbit which might have been due to trepanation; note the cicatrice to the right of the metopic suture (Cat. no. 49). *Left lower*, Paucarcancha. Cranium of adult female; trepanation by scraping in the left parietal and occipital near the lambda (Cat. no. 71). *Right lower*, Paucarcancha. Cranium of adult female; trepanation by scraping on left parietal above the lambdoid suture; only partially healed (Cat. no. 42).

Plate No. XXIII—*Left upper*, Paucarcancha. Cranium of adult female; depressed fracture in left parietal; the broken bone might have sloughed out or might have been removed by operation; healing process complete after inflamation (Cat. no. 128). *Right upper*, Paucarcancha. Cranium of adult male; trepanation by scraping in left parietal; healing process complete (Cat. no. 125). *Left lower*, Paucarcancha. Cranium of adult male; partial trepanation in left parietal (Cat. no. 127). *Right lower*, Paucarcancha. Cranium of adult female; trepanation by scraping in the frontal; completely cicatrized (Cat. no. 130).

PLATE XXIV—Paucarcancha. Youthful male. A case of trephining that did not heal (Cat. no. 75). See also PLATE III.

PLATE XXV—Paucarcancha. Adult male; trephining that did not hea
(Cat. no. 126).

PLATE XXVI—*Upper left,* Patallacta. Adult female; seriously fractured and trephined in two places; marks of the instrument still visible (Cat. no. 632). Lateral view. *Upper right,* Same as above. Norma verticalis. *Lower left,* Patallacta. Adult male; depressed fracture relieved by a slight operation; no healing (Cat. no. 640). *Lower right,* Patallacta. Adult male; depressed fracture followed by trephining; patient did not survive (Cat. no. 644).

PLATE XXVII—*Upper left*, Torontoy. Adult male; hopeless case of depressed fracture; the ragged margin of the opening and the numerous marginal striae reveal the character of the instrument used in performing the operation (Cat. no. 758). *Upper right*, Torontoy. Adult male; the only obvious case where trepanation was employed to remove diseased bone; the bone did not heal after the operation (Cat. no. 790; same as left lower fig. in Pl. V). *Lower left*, Huata. Adult male; fracture of the frontal relieved by trephining; the patient did not survive (Cat. no. 882). *Lower right*, Paucarcancha. Adult female; two partial trepanations in bilaterally symmetrical position back of the parietal eminences; a tiny hole marks the center of the one on the left parietal (Cat. no. 27).

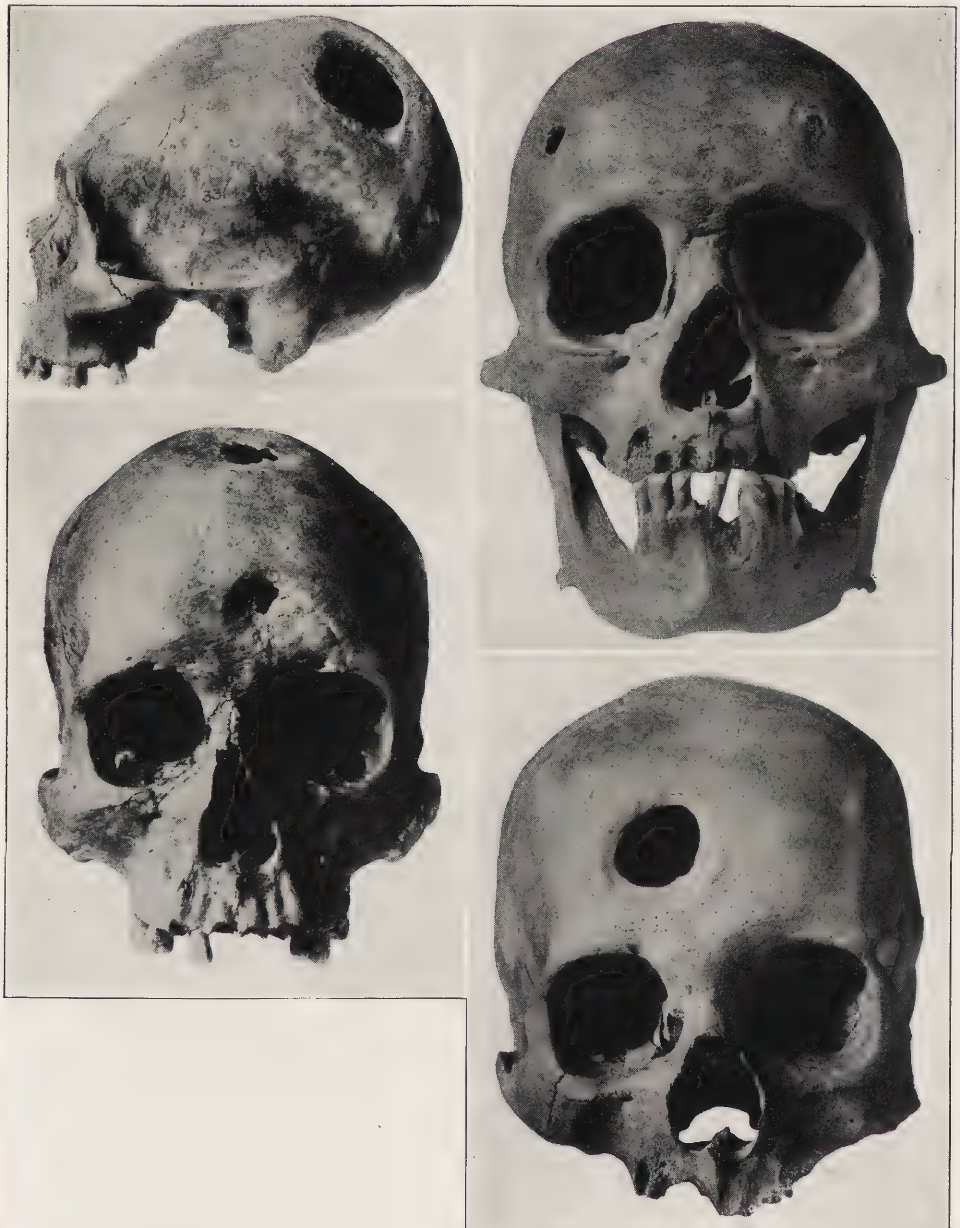


PLATE XXVIII—*Upper left,* Paucarcancha. Adult male; trepanation by the scraping process; healing complete (Cat. no. 33). *Upper right,* Paucarcancha. Adult male; trephining operation in the right temple two large cicatrices on the forehead (Cat. no. 40). *Lower left,* Patallacta. Adult male: trephining by scraping near the bregma; the aperture over the brow ridges might be due either to trephining or fracture; in both, the margins are completely healed (Cat. no. 629). *Lower right,* Patallacta. Adult male; trephining by scraping; margins healed (Cat no. 631).

PLATE XXIX—*Upper right*, Patallacta. Adult male; trephining by scraping; margins of aperture healed (Cat. no. 655). *Lower right*, Patallacta. Adult male; the large aperture in the left parietal is due to fracture followed by trepanation; margins healed (Cat. no. 633). *Upper left*, Patallacta. Adult male; trepanation by scraping over the right eye; healing process complete (Cat. no. 634). *Lower left*, Paucarcancha. Adult male; partial trepanation above right frontal tuber, apparently by scraping (Cat no. 24).

PLATE XXX—*Lower left,* Patallacta. Adult female; trepanation by scraping; healing process complete; the end of an impacted tooth is visible near the nasal spine (Cat. no. 746). *Upper left,* Huata. Adult male; trepanation by scraping; healing process complete; no sign of antecedent fracture (Cat. no. 878). *Upper right,* Huata. Adult male from cave no. 11; trepanation back of the left parietal eminence; another trepanation by scraping above the left frontal tuber; left cheek bone and nose broken and healed (Cat. no. 887). *Lower right* Yanamanchi. Adult male; large frontal trepanation to relieve a depressed, fracture; impacted left median incisor projects horizontally near the nasal spine (Cat. no. 911).

PLATE XXXI—*Upper left*, Paucarcancha. Adult female; small aperture in front of the left parietal eminence, probably the result of trepanation; healing process complete (Cat. no. 25). *Upper right*, Paucarcancha. Youth about 20 years old; partial trepanation affecting the left frontal and parietal (Cat. no. 26). *Lower left*, Paucarcancha. Adult male; external table has been removed from right parietal between obelion and lambda; healing process complete; may not be a case of trepanation (Cat. no. 28). *Lower right*, Paucarcancha. Adult male; trepanation or sabre stroke that barely penetrated the inner table in the left parietal near the sagittal suture (Cat. no. 30).

Plate XXXII—*Upper left*, Paucarcancha. Adult female; oval scar on the right half of the frontal near the coronal suture, probably caused by a wound (Cat. no. 39). See also mummy, fig. 1. *Upper right*, Paucarcancha. Adult male; large cicatrice on left frontal and parietal; might have been due to cauterization or trepanation by scraping (Cat. No. 41). *Lower left*, Paucarcancha. Adult male; a small perforation in the right parietal, due to some unknown cause (Cat. no. 46). *Lower right*, Paucarcancha. Male 20 years old; trepanation by scraping in the left parietal; healing process complete; atlas fused with occipital condyles (Cat. no. 122). See Pl. XXVIII, *upper left*,

Plate XXXIII—*Upper left*, Paucarcancha. Male 21 years old; large aperture in left frontal and parietal due to depressed fracture followed by trepanation; healing process complete (Cat. no. 123). See figs. 70 and 71, and P. V. *Upper right*, Paucarcancha. Adult male; trepanation in left half of frontal near coronal suture; healing process complete (Cat. no. 129). *Lower left*, Paucarcancha. Adult female; partial trepanation by scraping n occipital; bone partially healed (Cat. no. 165). *Lower right*, Paucarcancha. Adult male; trepanation by scraping or by cauterization in left half of frontal; partial trepanation in left parietal near the sagittal suture; healing process complete in both; skull affected by osteoporosis; alveolar abscess, caries, (Cat. no. 174).

Plate XXXIV—*Upper left*, Patallacta. Adult female; partial trepanation by scraping or by cauterization in the vertex; healing process complete; motive for the trepanation probably thaumaturgic (Cat. no. 630). *Upper right*, Adult male; partial trepanation by scraping or by cauterization in the right parietal near the lambdoid suture; healing process complete (Cat. no. 771). *Lower left*, Patallacta. Adult female; trepanation by scraping to relieve fracture in left parietal; healing process, complete; left zygomatic arch crushed in and healed (Cat. no. 660). *Lower right*, Patallacta. Adult male; depressed fracture in the left half of the frontal followed by inflamation; no visible evidence of trepanation (Cat. no. 638).

PLATE XXXV—*Left*, Patallacta. Youth about 20 years old; three depressed fractures, two in the occipital, and one in the left parietal; probably caused by stellate war club; no attempt to relieve them by operation(Cat. no. 637). *Right*, Paucarcancha. Adult male; great scar over the right orbit and nose (Cat. no. 36).

PLATE XXXVI—*Left*, Patallacta. Adult female cranium with excessive Aymara deformation with temporo-frontal articulation (reversed pterion) on both sides, and malplaced left canine (Cat. no. 636). *Right*, Tronotoy. Adult male skull with pronounced Aymara deformation; alveolar abscess (Cat. no. 760).

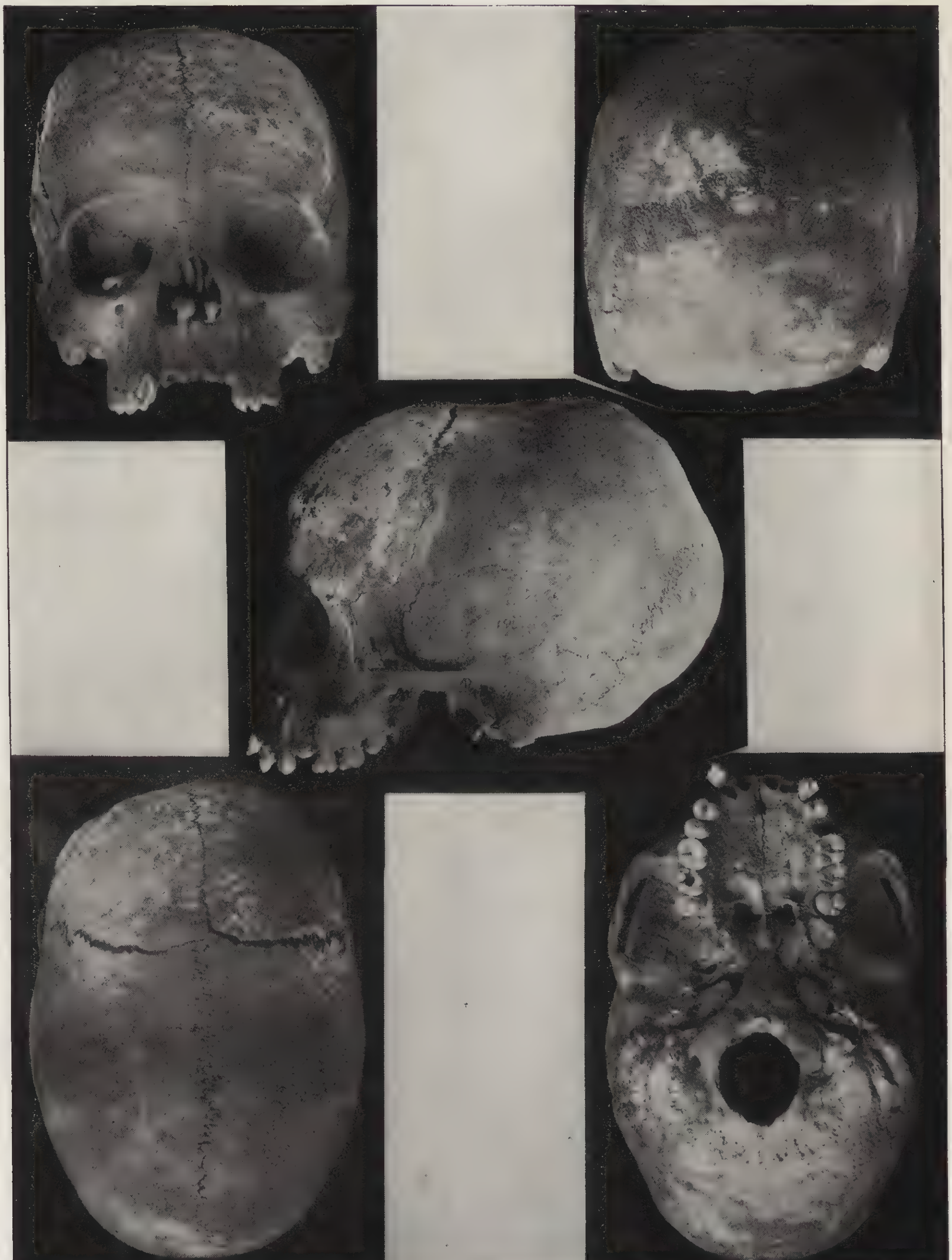


Plate No. XXXVII—Paucarcancha. Five aspects of cranium of adult female (Cat. no. 190). No. 1, frontal aspect; No. 2, posterior aspect; No. 3. lateral aspect; No. 4, vertical aspect; No. 5, basal aspect. Note the third condyle in the basal aspect; and the deformation known as cimbocephaly in the lateral and vertical aspects.

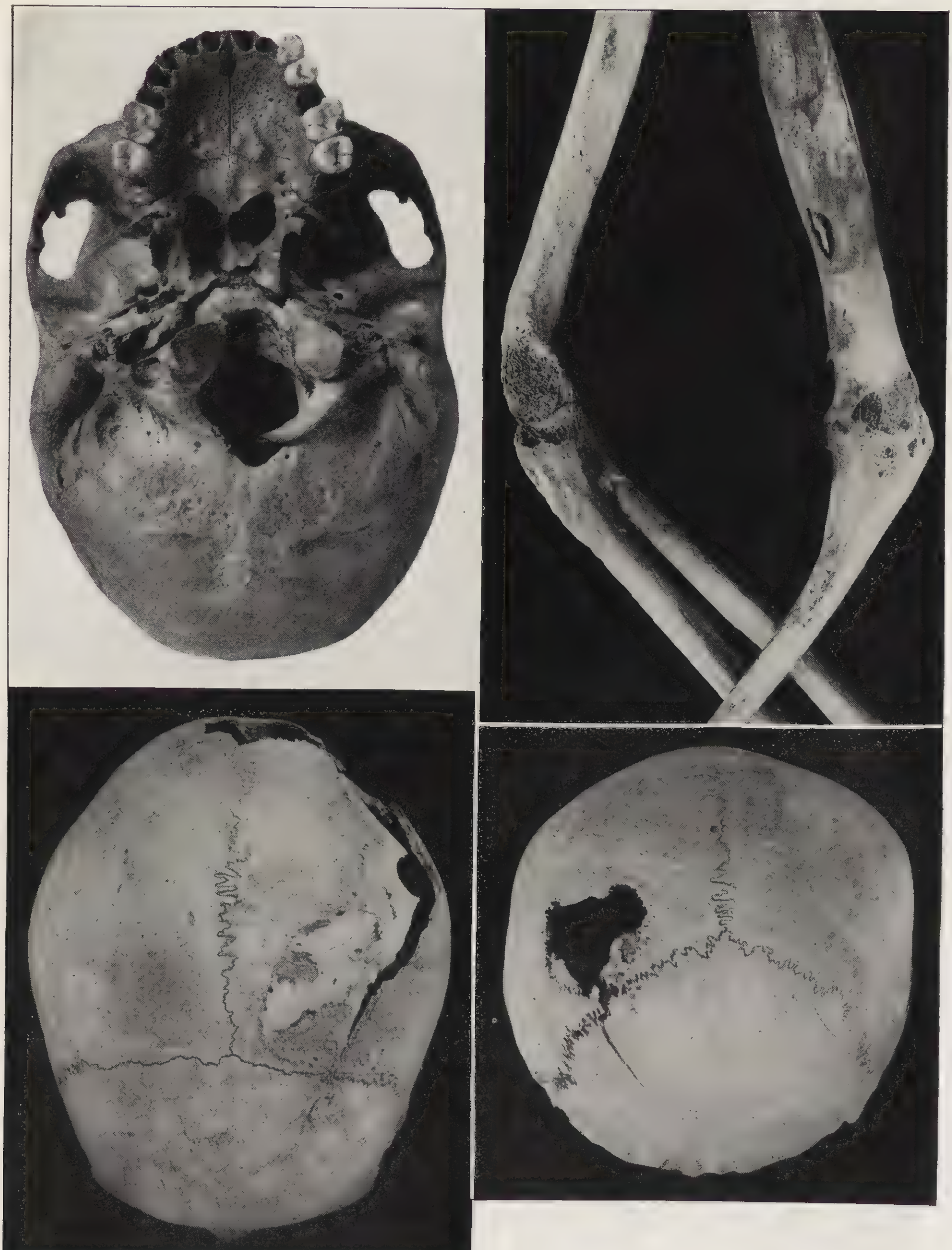


PLATE XXXVIII—*Upper right*, no. 1. Paucarcancha. Fusion of humerus, radius and ulna into a rigid joint (Cat. no. 270). No. 2. Huata. Fusion of humerus and ulna; an involucrum is visible a short distance above the rigid joint (Cat no. 901). *Upper left*, Paucarcancha. Youth 20 years old; atlas firmly fused with right occipital condyle and the margin of the foramen magnum on the right side and back of the hypoglossal canal (Cat. no. 122). See Pl. XXXII. *Lower left*, Child about 6 years old; disease, possibly sypnilic had affected the left half of the frontal and left parietal (Cat. no. 51). *Lower right*, Patallacta. Child about 8 years old; disease, possibly siphilitic, had destroyed portion of left parietal (Cat. no. 938).

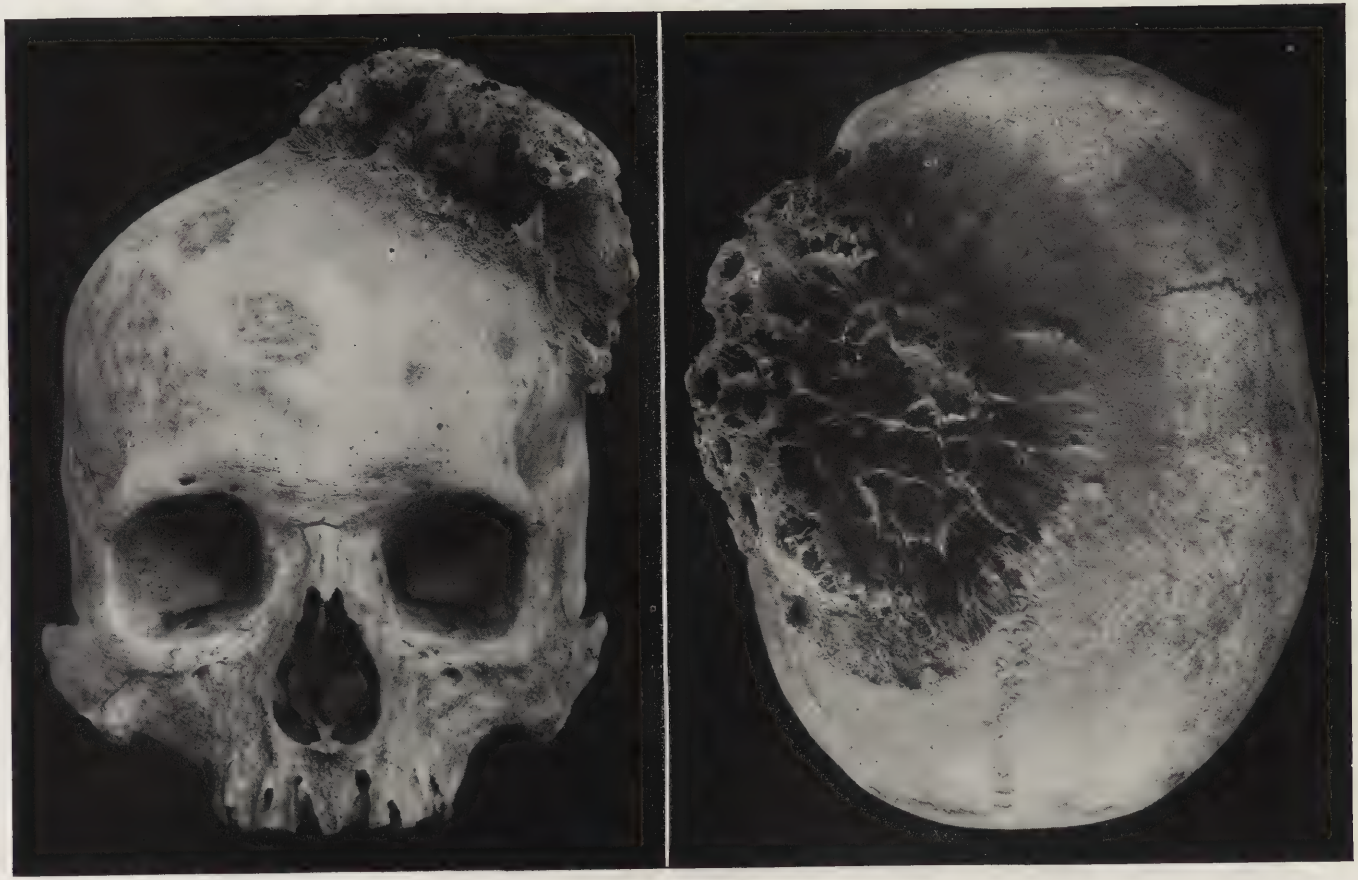


PLATE NO XXXIX—Paucarcancha. Adult male; Large bony excrescence due to osteosarcoma or bone cancer (Cat. no. 34). Frontal aspect. Vertical aspect.

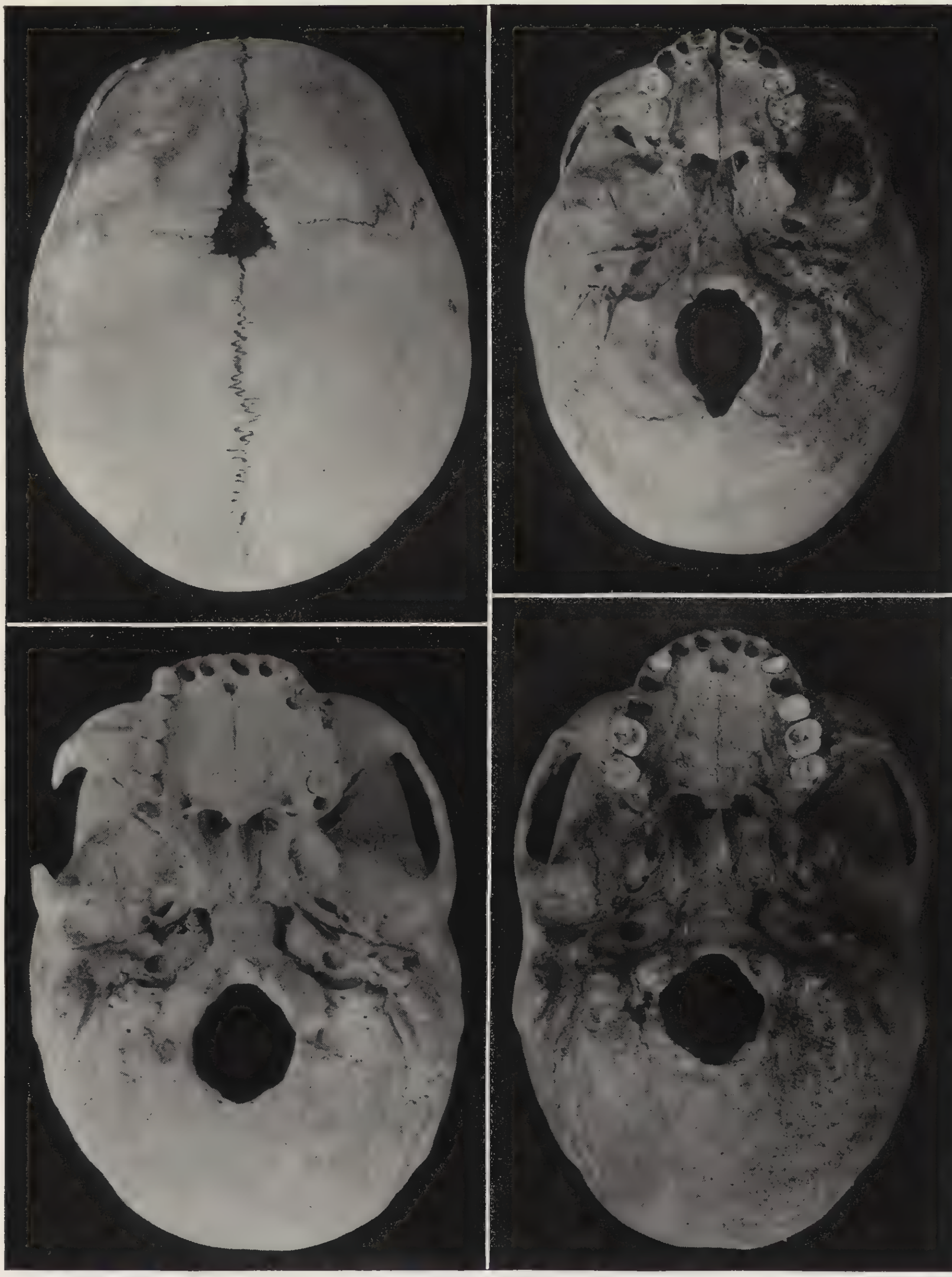


PLATE No. XL—*Upper left*, Sillque. Child at least 3 years old; persistence of the fontanelle and of the metopic suture (Cat. no. 917). Vertical aspect. *Upper right*, Basal aspect of same cranium, showing node of Kerckering, or failure of the occipital bone to develop in the region of the episthion.
Lower left, Basal aspect of adult female (Cat. no. 657) showing third or median occipital condyle. *Lower right*, Torontoy. Adult female; large paracondyloid or paramastoid processes that articulate with the atlas (Cat. no. 769). Basal aspect.

PLATE No. XLI—*Lower right*, Patallacta. Adult male; disease rsembling syphilitic necrosis on right frontal and parietal and left parietal (Cat. no. 635).

Upper right, Patallacta. Adult female; persistence of the squamomastoid suture (Cat. no. 657). Lateral aspect.

Upper left, Lateral aspect of female cranium No. 769. Prominent processus marginalis on the frontal process of the molar bone. *Lower left*, Paucarcancha. Male about 21 years old; persistence of milk canines causing displacement of the left permanent canine and impacting the right permanent canine (Cat. no. 123). See Pls. XXXIII and XLII.

Plate No. XLII—*Lowermost fig.*, Same cranium as that in Pl. XLI, left lower figure. Radiograph of palate aspect showing impacted right permanent canine. *Two upper figs.*, Paucarcancha. Dental aspect of two lower jaws, showing alveolar abscesses (Cat. nos. 215 and 243).

Plate No. XLIII—*Left, no.* 1. Paucarcancha. Fusion of manubrium with mesosternum (Cat. no. 160). No. 2. Paucarcancha. Perforate mesosternum and fusion of xiphi-sternum with mesosternum (Cat. no. 282). No. 3. Torontoy. Mesosternum very slender in proportion to its length (Cat. no. 813). *Right,* No. 1. Torontory. Female sacrum in which ala failed to develop and the entire first segment has not fused with the second segment (Cat. no. 782). No. 2. Huispang. Dorsal aspect of male sacrum showing failure of the posterior arch of the second segment to develop (Cat. no. 921). No. 3. Paucarcancha. Female sacrum; right ala of the first segment is not developed and the body of the first segment is not fused with the second (Cat. no. 190). No. 4. Paucarcancha. Female sacrum with only four segments (Cat. no. 295).

PLATE XLIV—*Left*, Paucarcancha. Adult male: very early injury to spinal column resulting in lateral curvature; fusion of neck vertebrae and of ribs; presence of two wedge-shaped supernumerary vertebrae; 13 rib scars on the right side; the first four ribs on the left side are fused with the vertebrae (Cat. no. 300.) *Right*, nos. 1 and 2. Right male tibia of ordinary size (Cat. no. 923.) from Huarocondo compared with short robust right male tibia (Cat. no. 460). from Paucarcancha. No. 3. Huata. Broken upper half of right tibai of which the two parts failed to join (Cat. no. 900). No. 4. Torontoy. Adult male; compound fracture with sloughing out of bone fragment just above the elbow joint (Cat. no. 821).

PLATE No. XLV—Patallacta. Adult male pelvis. No. 1, anterior aspect; No. 2, posterior aspect showing the failure of the posterior arches of all five sacral segments to develop (Cat. no. 1029).

Plate No. XLVI—Paucarcancha. Posterior aspect of the sacrum of an adult female; the posterior arch of the first segment has failed to develop (Cat. no. 461). Paucarcancha. Sacrum and part of the vertebral column of an adult of uncertain sex; note the presence of a right first lumbar rib; of a short fifth left lumbar transverse process; the failure of the body the first sacral segment to fuse with that of the second; and the fusion of the first coccygial segment with the fifth sacral segment (Cat. no. 390.) Paucarcancha. A pair of femora with processes above median condyle (Cat. no. 334). Huata. Left femur of a male with third trochanter (Cat. no. 902).

PLATE No. XLVII—Paucarcancha. A pair of mushroom femora and the right inominate bone showing enlarged but shallow acetabulum; arthritis deformans (Cat. no. 274). Patallacta. Complete fusion of the first and second ribs on the left side (Cat. no. 712). Patallacta. Two lumbar vertebrae seriously affected by arthritis deformans (Cat. no. 715). Patallacta. Adult female lower jaw in which the two first molars and the left third molar each have three roots (Cat. no. 687).

Plate No. XLVIII—Patallacta. Right adult male tibia fused with astragalus and calcaneum (Cat. no. 714). Fibula belonging with No. 1; the distal end is enlarged because of injury to the ankle joint. Paucarcancha. Fibula of which the distal end is much enlarged by an injury (Cat. no. 273). Paucarcancha. Right adult female tibia fused with astragalus due to an injury on the median malleolus (Cat. no. 277). Paucarcancha. Oblique fracture of right tibia and fibula (Cat. no. 268). Paucarcancha. Left tibia of adult male with enlarged shaft and fistula due to an injury (Cat. no. 282a). Paucarcancha. Left tibia that had been affected either by arthritic lesion or by a comminuted fracture of the knee joint (Cat. no. 269).

Plate XLIX—Paucarcancha. Three syphilitic (?) tibia, one of which is the longest in the collection (Cat. nos. 272, 288a and 283a). Patallacta. A pair of syphilitic (?) tibae (Cat. no. 1006). Patallacta. Syphilitic (?) humerus (Cat. no. 1008).

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PHYSICAL MODIFICATIONS OF THE POPULATION OF RUSSIA UNDER FAMINE

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MATERIAL

When it became apparent that a period of famine was approaching in Russia and that it threatened to be of long duration, the author enlisted his colleagues in an anthropometric investigation of the physical effects of starvation. The observations were made on adults and children in different parts of Russia and were continued for three years. All the measurements reported herein were repeated at intervals of six months. Thus each individual was examined six times. The present paper, is, however, limited to some of the changes observed in adults.

The data extend to 2,114 individuals, 1,284 males, 25 to 55 years of age, and 830 females, 20 to 55 years of age, belonging to the following groups:

	Males	Females
1. Great Russians, Tver Province	76	48
" " Ryasan	102	75
" " Koursk	55	52
" " Erivan	80	54
Total, Great Russians	313	229
2. Ukrainians, Kiev Province	83	55
" Ekatarinoslav Province	67	45
" Tauride Province	100	100
Total, Ukrainians	250	200

[1]Translated from the original MS by Waldemar Jochelson; Edited by A. H.

	Males	Females
3. White Russians, Minsk Province	56	44
Armenians, Erivan Province	88	36
Georgian-Gruzins, Tiflis Province	105	63
Tartars, Crimea	70	
Zyrians, Oust-Dvinsk, Province	78	50
Permiak, Perm Province	90	62
Bashkir, Orenburg Province	67	43
Kalmuck, Astrakhan Province	82	45
Kirghiz	85	58
Total,	1284	830

CHANGES IN STATURE

In the normal course of man's life there are three principal periods during which stature phenomena are noted: first, the period of growth, or enlargement, which lasts from the embryonic stage to the time when the organism attains complete development. The age at which growth ceases has been variously estimated. According to observations reported on Europeans, growth continues up to from 22 to 25 years—according to Pfitzner even to 35 years—in males, and from 18 to 22 years among females. Second, from 25 to 50 years stature does not change appreciably; at least, so it was believed up to the present. After 50 years of age stature begins gradually to diminish.

Properly speaking, stature never remains the same. It is subject to characteristic changes even in the course of a single day. In the morning, after a night's rest, the stature is greater than in the evening. After a long period of standing, walking, or carrying a burden, stature may diminish by as much as 5 cm. The most rapid diminution may be observed early in a long period of standing, later it is less marked. These phenomena may be explained by the compression of the fibro-cartilaginous inter-vertebral disks which under pressure become thinner and produce in consequence a diminution of the length of the vertebral column. According to Deniker, "unscrupulous recruits whose stature is close to the prescribed limits well know that by carrying very heavy burdens on the eve of their examinations by the council of revision they can compress their intervertebral disks in such a way that the stature is sometimes decreased 3 centimeters."

Tables 1 to 3 show the degree of diminution of stature of Russian and surrounding peoples under the influence of inanition. It is important to note that this diminution in stature occurred in adults at an age when it was thought that stature did not change. Among the Great Russians the average diminution among males was found to be 4.7 cm., among females, 3.5 cm.

TABLE 1

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	1672	1620	1566	1520
" " " " Riasan	1644	1602	1528	1495
" " " " Koursk	1656	1614	1547	1518
" " " " Erivan	1666	1616	1550	1530
Average, Great Russians	1659	1612	1545	1510
Ukrainians, Province of Kiev	1655	1610	1546	1508
" " " Ekaterinoslav	1664	1618	1572	1524
" " " Tauride	1658	1622	1566	1526
Average, Ukrainians	1658	1616	1561	1520
White Russians, Province of Minsk	1658	1619	1569	1530
Armenians, " " Erivan	1671	1633	1572	1536
Georgians-Gruzins, " " Tiflis	1653	1611	1570	1533
Tartar, Crimea	1644	1583		
Zyrian, Province of Oust-Dvinsk	1626	1578	1531	1483
Permiak " " Perm	1625	1574	1522	1477
Bashkir, " " Orenburg	1643	1595	1554	1512
Kalmuck, " " Astrakhan	1632	1580	1498	1456
Kirghiz	1650	1606	1568	1530

TABLE II—STATURE OF MALES

	Before the Famine				After the Famine			
	% 1600	% 1601–1650	% 1651–1700	% 1701	% 1600	% 1601–1650	% 1651–1700	% 1701
Great Russians, Province of Tver	17	27	33	23	23	36	28	13
" " " " Riasan	23	36	28	13	27	39	22	12
" " " " Koursk	22	39	21	18	27	44	18	11
" " " " Erivan	18	42	23	17	25	47	9	9
Average, Great Russians	20	36	26	18	25	42	21	12
Ukrainians, Province of Kiev	15	29	37	19	19	35	33	13
" " " Ekaterinoslav	17	19	32	32	22	24	28	26
" " " Tauride	24	41	20	95	27	46	17	10
Average, Ukrainians	19	29	30	22	23	35	26	16
White Russians, Province of Minsk	18	43	31	8	22	47	27	4
Armenians, Province of Erivan	14	24	36	26	17	29	31	23
Georgians-Gruzins, Province of Tiflis	19	30	30	21	23	36	26	15
Tartar, Crimea	12	37	36	15	19	44	28	9
Zyrian, Province of Oust-Dvinsk	11	35	33	21	16	39	28	17
Permiak, Province of Perm	14	32	38	16	20	37	32	11
Bashkir, " " Orenburg	15	27	33	25	20	33	28	19
Kalmuck, " " Astrakhan	18	36	27	19	22	43	23	12
Kirghiz	10	33	30	18	21	41	27	11

TABLE III—STATURE OF FEMALES

	Before the Famine				After the Famine			
	1400 %	1401–1530 %	1531–1580 %	1581 %	1400 %	1401–1530 %	1531–1580 %	1581 %
Great Russians, Province of Tver	4	38	47	11	11	43	39	7
" " " " Riasan	14	41	37	8	17	45	32	6
" " " " Koursk	6	41	35	18	9	47	30	14
" " " " Erivan	5	40	45	10	10	46	38	6
Average, Great Russians	7	40	41	12	12	45	35	8
Ukrainians, Province of Kiev	8	36	38	18	11	42	33	14
" " " Ekaterinoslav	17	39	42	2	25	43	32	
" " " Touride	13	41	31	15	17	45	25	13
Average, Ukrainians	13	39	37	11	18	43	30	9
White Russians, Province of Minsk	3	44	40	7	12	48	35	5
Armenians, " " Erivan	11	39	39	11	16	43	33	8
Georgians-Gruzins " " Tiflis	8	42	33	17	14	46	27	13
Zyrian, Province of Oust-Dvinsk	12	40	38	10	16	46	33	5
Permiak, " " Perm	10	43	35	12	13	47	32	8
Bashkir, " " Orenburg	13	38	37	12	17	42	31	10
Kalmuck, " " Astrakhan	16	42	33	9	22	48	25	5
Kirghiz	14	35	40	11	19	41	33	7

The diminution in stature among other peoples in Russia was about the same. The average decrease was from 3.8 to 6.1 cm. in males and from 3.6 to 4.8 cm. in females. Consequently, variation in stature

	Males cm.	Females cm.
Ukrainians	4.2	4.1
White Russians	3.9	3.9

under fasting was less marked among females than males. Stature underwent considerable diminution among the Tartars of Crimea, the average loss being 6.1 cm., but at times the diminution was as high as 9.1 cm.

Dividing the persons examined into two groups, those whose stature averaged higher than 165 cm. in males and 153 cm. in females, and those lower, we found that after the period of famine, a part of the taller group has passed over to the shorter group. This passing over from the taller to the shorter group was seen in from 8 per cent of the males (Armenians, White Russians) to 14 per cent (Tartars, Crimea) and among females in from 7 per cent (White Russians, Permiaks) to 12 per cent (Kalmuck). In both sexes in individuals of high stature the

decrease was greater than in those of low stature. And stature of intellectuals was found generally to decrease more than that of laborers.

Those who had suffered from contagious diseases (particularly typhus), were found to have suffered greater diminution in height than those who were healthy. Stature further decreased more in the winter than in the summer. Among the married with families stature diminished more than among bachelors.

In studying variations in stature according to age, it was established that its diminution was less rapid among those above forty than those under. However, after three years of famine, the actual decrease in stature of the older group was greater than in the younger group. Stature diminished considerably during the first half year of famine and also during the second half year, but later on, although hunger continued, the decrease was very slow or ceased entirely. In other words, stature suffered a maximum loss under the influence of famine in the first year and then ceased to react.

When diet improved, stature increased until it reached the normal stage as food became sufficient. The return to normal was not sudden, but extended over a period of a month or six weeks from the day the diet became regular. If the normal diet became the rule, there appeared to be a tendency for stature to exceed the pre-famine level. This augmentation was, however, insignificant and was observed only on individuals under forty years.

When the groups (Great Russians, Ukrainians, White Russians) were classified according to hair and eye color into fair, mixed, and dark, it was noticed that the fair group showed a greater diminution of stature than the individuals of the other two types (5.2 cm. among males and 4.3 cm. among females). Next in order was the dark group with a diminution of 4.6 cm. in males, and 3.8 cm. in females, while the stature of the mixed group was found to decrease but 3.6 cm. in males and 3.3 cm. in females. Decrease in stature was less among brachycephals than among dolichocephals.

Have these diminutions in height in the different groups contributed to the accentuation or to the levelling of the differences which exist between them? An examination of Table 1 will show that the differences in the statures of males have increased; on the contrary, the group differences in the statures of females have decreased. The difference in the stature of the two sexes has distinctly decreased under

the influence of fasting among all the groups, except the Zyrians, with whom the relation did not vary.

HEAD AND FACE

Measurements of the head and face were made, to establish the degree of modification of morphological traits of the skull and face as well as of their different parts. These investigations have shown that the volume of the head (soft parts) and the length from the vertex to the chin have decreased. The reduction of this length, however, (Table 4) although shown in individuals of different groups, is rather insignificant. It varies in average from 5 mm. (White Russians) to 12 mm. (Bashkir) among males, and from 7 mm. (Armenians, Bashkir) to 12 mm. (Permiak) among females.

TABLE IV—LENGTH OF HEAD
(Vertex to Chin)

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	219	208	206	195
" " " " Riasan	221	211	206	194
" " " " Koursk	216	208	204	196
" " " " Erivan	216	203	207	198
Average, Great Russians	218	208	206	196
Ukrainians, Province of Kiev	222	210	211	200
" " " Ekaterinoslav	220	208	211	203
" " " Tauride	214	205	205	196
Average, Ukrainians	218	207	208	198
White Russians, Province of Minsk	215	210	204	193
Armenians, " " Erivan	217	209	205	198
Georgians-Gruzins, " " Tiflis	213	204	199	191
Tartars, Crimea	214	206		
Zyrian, Province of Oust-Dvinsk	216	206	204	193
Permiak, " " Perm	221	212	200	197
Bashkir, " " Orenburg	220	208	212	205
Kalmuck, " " Astrakhan	224	215	213	202
Kirghiz	222	216	214	207

TABLE V—RELATION OF HEAD LENGTH TO STATURE

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver.....	13.09	12.77	13.22	12.78
" " " " Riasan...	13.44	13.17	13.48	12.97
" " " " Koursk...	13.04	12.83	13.18	12.91
" " " " Erivan...	12.95	12.56	13.35	12.95
Average, Great Russians........	13.16	12.89	13.33	12.91
Ukrainians, Province of Kiev.........	13.41	13.04	13.65	13.26
" " " Ekaterionslav.	13.22	12.85	13.42	13.32
" " " Tauride......	12.91	12.64	13.09	12.84
Average, Ukrainians............	13.15	12.81	13.32	13.03
White Russians, Province of Minsk...	12.97	12.97	13.00	12.61
Armenians, Province of Erivan.......	12.98	12.80	13.04	12.89
Georgians-Gruzins, Province of Tiflis..	12.89	12.66	12.67	12.46
Tartar, Crimea....................	13.02	13.01		
Zyrian, Province of Oust-Dvinsk.....	13.28	13.05	13.32	13.01
Permiak, " " Perm...........	13.60	13.46	13.73	13.33
Bashkir, " " Orenburg........	13.40	13.04	13.64	13.56
Kalmuck, " " Astrakhan.......	13.73	13.61	14.22	13.87
Kirghiz..........................	13.42	13.45	13.65	13.53

The relation between head length and stature (Table 5) decreased under the influence of famine among all the groups except the Kirghiz, among whom it remained almost the same as before the famine: *13.42* before and *13.45* after the famine. Among the groups at present under consideration, the relative size of the head (with relation to stature) is lower in high stature and higher with low stature. For that reason women who have shorter stature than men (the difference varies from 10 to 12 cm.), generally have a relatively larger head. Only the Georgian-Gruzins were an exception: the relative dimensions of the head were found to be larger among men (12.89) than among women (12.67). After the famine this law no longer applied to certain groups:

	Males	Females
White Russians....................................	12.97	12.61
Gruzins...	12.66	12.44
Zyrian..	13.05	13.01
Permiak...	13.46	13.33

The horizontal circumference of the head (Table 6) also diminished under the influence of inanition and that in all the ethnic groups under observation. Among males this diminution appeared to be greater than among females, averaging from 1.3 to 2.3 cm. for males, and from 1.2 to 2.1 cm. for females.

TABLE VI—HORIZONTAL CIRCUMFERENCE OF THE HEAD

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	552	537	534	522
" " " " Riasan	544	519	526	495
" " " " Koursk	549	532	531	518
" " " " Erivan	555	536	537	521
Average, Great Russians	550	529	531	512
Ukrainians, Province of Kiev	563	538	540	517
" " " Ekaterinoslav	554	534	536	520
" " " Tauride	547	531	529	515
Average, Ukrainians	554	534	533	516
White Russians, Province of Minsk	554	536	535	518
Armenians, Province of Erivan	555	536	541	525
Georgians-Gruzins, Province of Tiflis	551	537	538	524
Tartars, Crimea	548	535		
Zyrian, Province of Oust-Dvinsk	551	532	529	511
Permiak, Province of Perm	548	531	526	509
Bashkir, " " Orenburg	558	539	539	518
Kalmuck, " " Astrakhan	565	542	543	528
Kirghiz	565	536	537	520

TABLE VII—ANTERO-POSTERIOR AND TRANSVERSE DIAMETERS OF HEAD

	Antero-Posterior Diameter				Transverse Diameter			
	Males		Females		Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	181	176	176	172	150	142	147	140
" " " " Riasan	185	182	181	178	152	146	148	142
" " " " Koursk	184	180	179	177	151	145	149	143
" " " " Erivan	186	183	182	179	152	146	150	144
Average, Great Russians	184	181	180	177	152	145	148	142
Ukrainians, Province of Kiev	187	183	182	178	157	151	154	147
" " " Ekaterinoslav	184	181	178	176	153	145	150	144
" " " Tauride	182	179	180	177	152	146	150	144
Average, Ukrainians	185	181	181	177	154	147	152	145
White Russians, Province of Minsk	184	181	182	179	150	144	148	141
Armenians, Province of Erivan	182	178	180	172	156	154	156	153
Georgians-Gruzins, Province of Tiflis	183	179	179	177	153	152	151	148
Tartars, Crimea	184	181			151	150		
Zyrian, Province of Oust-Dvinsk	185	182	179	178	153	147	149	143
Permiak, Province of Perm	185	183	181	179	150	145	148	142
Bashkir, Province of Orenburg	181	178	177	176	151	145	146	143
Kalmuck, Province of Astrakhan	182	179	178	177	152	144	148	144
Kirghiz	183	181	181	178	158	153	153	148

An interesting change has occurred in the antero-posterior and the transverse diameter of the head (Table 7). These diameters have both diminished but in different proportions; the transverse diameter in the

majority of cases has shortened more (from 1 to 8 mm. among males and from 3 to 7 mm. among females) than the antero-posterior diameter, which decreased from 2 to 4 mm. among males and from 1 to 4 mm. among females. The result, as we shall see later, was a slight lowering of the cephalic index. Three groups, however, were exceptions to this rule; among the Armenians, Gruzins, and Tartars of Crimea, the transverse diameter underwent less diminution than the antero-posterior, which resulted in the increase of the number of brachycephals. The famine caused, therefore, a perceptible change in the cephalic index among all the Russian groups (Tables 8 and 9), but these changes were not in the same direction. The cephalic index among Great Russian

Table VIII—Cephalic Index

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver....	82.67	80.45	83.33	79.88
" " " " Riasan..	82.78	80.46	81.12	79.66
" " " " Koursk..	82.04	80.00	83.16	79.76
" " " " Erivan..	82.02	79.68	82.16	80.12
Average, Great Russians.......	82.43	80.18	82.29	79.70
Ukrainians, Province of Kiev.......	84.46	82.28	84.92	82.10
" " " Ekaterinoslav	83.33	80.16	84.26	81.76
" " " Tauride.....	83.12	81.32	83.18	81.44
Average, Ukrainians...........	83.62	81.33	83.89	81.69
White Russians, Province of Minsk..	81.67	79.78	81.14	78.56
Armenians, Province of Erivan......	85.11	86.74	86.74	86.32
Georgians-Gruzins, Province of Tiflis.	83.62	85.25	84.18	83.56
Tartars, Crimea..................	82.05	82.77		
Zyrian, Province of Oust-Dvinsk.....	82.43	80.12	83.26	80.76
Permiak, Province of Perm.........	81.28	79.64	82.06	79.58
Bashkir, Province of Orenburg......	83.36	81.44	82.71	81.16
Kalmuck, Province of Astrakhan....	83.00	80.66	83.33	81.56
Kirghiz.........................	85.14	84.18	84.82	82.25

Table IX—Cephalic Index

	Males					
	Before the Famine			After the Famine		
	Dolicho-cephalic 77.77	Meso-cephalic 77.78-80.	Brachy-cephalic 80.01%	Delico-cephalic	Meso-cephalic	Brachy-cephalic
	%	%	%	%	%	%
Great Russians, Province of Tver.....	8	18	74	13	20	67
" " " " Riasan...	3	26	71	8	31	61
" " " " Koursk...	9	21	70	14	22	64
" " " " Erivan...	4	18	78	9	15	76

	Dolicho-cephalic 77.77 %	Meso-cephalic 77.78-80. %	Brachy-cephalic 80.01% %	Delico-cephalic %	Meso-cephalic %	Brachy-cephalic %
Average, Great Russians	6	21	73	11	22	67
Ukrainians, Province of Kiev	2	15	83	10	23	67
" " " Ekaterinoslav	6	23	71	10	22	68
" " " Tauride	4	13	83	10	18	72
Average, Ukrainians	4	17	79	10	21	69
White Russians, Province of Minsk	8	19	73	13	25	62
Armenians, Province of Erivan		2	98		1	99
Georgians, Province of Tiflis	4	13	83	2	15	83
Tartars, Crimea		8	92		8	92
Zyrian, Province of Oust-Dvinsk	9	27	64	14	26	60
Permiak, Province of Perm	8	25	67	13	32	55
Bashkir, Province of Orenburg		32	68	5	37	58
Kalmuck, Province of Astrakhan		35	65	3	38	59
Kirghiz		24	76	3	28	69

Table IX—Cephalic Index (Continued)

	Females					
	Before the Famine			After the Famine		
	Dolicho-cephalic	Meso-cephalic	Brachy-cephalic	Dolicho-cephalic	Meso-cephalic	Brachy-cephalic
Great Russians, Province of Tver	5	16	79	11	21	68
" " " " Riasan	8	22	70	13	29	58
" " " " Koursk	7	17	76	15	15	70
" " " Erivan	9	22	69	13	23	64
Average, Great Russians	7	19	74	13	22	65
Ukrainians, Province of Kiev	3	15	82	10	23	57
" " " Ekaterinoslav	3	20	77	9	18	73
" " " Tauride	6	16	78	14	24	62
Average, Ukrainians	4	17	79	11	22	67
White Russians, Province of Minsk	7	19	74	12	24	64
Armenians, Province of Erivan		2	98		1	99
Georgians, Province of Tiflis	4	14	82	5	15	80
Tartars, Crimea						
Zyrian, Province of Oust-Dvinsk	6	23	71	9	28	63
Permiak, Province of Perm	7	24	69	12	27	61
Bashkir, Province of Orenburg	2	34	64	6	36	58
Kalmuck, Province of Astrakhan		36	64	2	38	60
Kirghiz	1	26	73	5	32	63

males in all provinces modified in the direction of dolichocephaly. The average cephalic index of 82.43 was lowered to 80.18. The number of dolichocephals which varied from 3 to 4 now vary from 8 to 14 per cent, while the number of brachycephals dropped from 70 to 78 to 61 to 76 per cent, i. e., in average from 73 to 67 per cent. Dolichocephaly also became more frequent with the Ukrainians and White Russians. With the first, the average cephalic index dropped from 85.62 to 81.33 and the

number of dolichocephals rose from 4 to 10 per cent; the number of brachycephals fell from 79 to 69 per cent. With the second the average cephalic index fell from 81.67 to 79.78. The number of dolichocephals rose from 8 to 13 per cent and the number of brachycephals fell from 73 to 63 per cent.

The cephalic index of Russian women fell also. Among the Great Russian and White Russian women the cephalic index dimished more than with the men. Consequently, the number of dolichocephals rose from 7 to 13 per cent, with the Ukrainian women from 4 to 11 per cent, with the White Russian women from 7 to 12 per cent. The number of brachycephals among the females fell from 74 to 65 (Great Russian women), from 79 to 67 (Ukrainian women), and from 74 to 64 per cent (White Russian women). Among the Russians, individuals of fair type manifested a more pronounced tendency to dolichocephaly than the dark and mixed types. Comparing those over 49 years of age with younger individuals, we found that the cephalic index in the first modified more in the direction of dolichocephaly than in the second.

The cephalic index of the Zyrians, Bashkir, Kalmuck, and Kirghiz of both sexes diminished in almost the same proportions as that of the Russians. The number of dolichocephals among them, as among the Russians, was increased and the number of brachycephals diminished With the Armenians, Gruzins, and Tartars of Crimea, the cephalic index changed in the opposite direction; it had not dimished, but on the contrary, had increased. Under the influence of famine the brachycephaly of these three tribes became more prominent. It should be noted that the shift toward brachycephaly was observed only among the males. Among Armenian and Gruzin females, as among the women of other groups, the cephalic index diminished, although in an insignificant way.

TABLE X—LENGTH AND BREADTH OF FACE

	Length				Width			
	Males		Females		Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	180	177	171	168	138	133	131	126
" " " " Riasan	181	177	172	170	139	133	129	126
" " " " Koursk	183	180	174	171	140	136	132	127
" " " " Erivan	179	176	169	166	138	135	130	126
Average, Great Russians	181	177	172	169	139	134	131	126

	Before the Famine	After the Famine	Before the Famine	After the Famine	Before the Famine	After the Famine	Before the Famine	After the Famine
Ukrainians, Province of Kiev	181	177	173	170	139	133	132	129
" " " Ekaterinoslav	182	179	174	171	141	137	136	130
" " " Tauride	180	176	172	168	138	134	135	131
Average, Ukrainians	181	177	173	169	139	134	134	130
White Russians, Province of Minsk	182	179	175	171	139	135	133	128
Armenians, Province of Erivan	183	180	176	172	144	138	139	132
Georgians, Province of Tiflis	180	178	171	168	139	134	131	126
Tartars, Crimea	179	176			142	136		
Zyrians, Province of Oust-Dvinsk	178	176	170	167	138	133	131	125
Permiaks, Province of Perm	179	176	171	169	137	132	132	127
Bashkir, Province of Orenburg	182	178	174	172	146	140	140	136
Kalmuck, Province of Astrakhan	185	182	177	174	151	146	143	137
Kirghiz	182	180	177	175	147	144	146	141

Modifications that under fasting appeared in the dimensions of the face (height, breadth, Table 10) and in the facial index (Tables 11 and 12), are analagous to changes in the dimensions of the skull. The height

TABLE XI—FACIAL INDEX

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	76.66	75.14	76.61	75.50
" " " " Riasan	76.79	75.14	75.00	74.12
" " " " Koursk	76.50	75.55	75.86	74.27
" " " " Erivan	77.09	76.70	76.92	75.90
Average, Great Russians	76.78	75.61	75.98	74.76
Ukrainians, Province of Kiev	76.80	75.14	76.30	75.29
" " " Ekaterinoslav	77.47	76.54	78.16	76.02
" " " Tauride	76.66	74.14	78.37	77.98
Average, Ukrainians	76.92	75.12	77.75	76.79
White Russians, Province of Minsk	76.37	75.42	76.00	74.85
Armenians, Province of Erivan	78.69	76.66	78.98	76.74
Georgians, Province of Tiflis	77.22	75.28	76.61	75.00
Tartars, Crimea	79.33	77.27		
Zyrian, Province of Oust-Dvinsk	77.53	75.57	77.06	74.85
Permiak, Province of Perm	76.54	75.00	77.18	75.13
Bashkir, Province of Orenburg	80.23	78.65	80.46	79.07
Kalmuck, Province of Astrakhan	81.62	80.22	80.79	78.73
Kirghiz	80.79	80.00	82.43	80.57

of face, measured from the hair line to the chin, diminished relatively less (from 2 to 4 mm. in both sexes) than the width (from 3 to 6 mm. among males and from 4 to 7 mm. among females). This resulted in a diminution of the facial index. In other words, the face became narrower, more leptoprosopic. This change was more marked in females than males.

TABLE XII—FACIAL INDEX

	Males					
	Before the Famine			After the Famine		
	Leptoprosopic under 70.00	Mesoprosopic 70.01–80.00	Chameprosopic 80.01 & over	Leptoprosopic	Mesoprosopic	Chameprosopic
Great Russians, Province of Tver	4	75	21	6	75	19
" " " " Riasan	8	68	24	5	71	24
" " " " Koursk	5	69	26	10	70	20
" " " " Erivan	5	70	25	9	78	13
Average %, Great Russians	6	70	24	7	74	19
Ukrainians, Province of Kiev	7	67	26	11	71	18
" " " Ekaterinoslav	7	77	16	10	69	21
" " " Tauride	6	72	22	10	77	13
Average %, Ukrainians	7	72	21	10	72	18
White Russians, Province of Minsk	4	78	18	10	78	12
Armenians, Province of Erivan	3	59	38	5	65	30
Georgians, Province of Tiflis	1	58	41	4	57	39
Tartars, Crimea	2	68	30	6	68	26
Zyrian, Province of Oust-Dvinsk	4	57	39	9	60	31
Permiak, Province of Perm	5	62	33	8	68	24
Bashkir, Province of Orenburg	2	58	40	5	61	34
Kalmuck, Province of Astrakhan		53	47	3	56	41
Kirghiz	1	57	42	3	61	36

TABLE XII—FACIAL INDEX (Continued)

	Females					
	Before the Famine			After the Famine		
	Leptoprosopic	Mesoprosopic	Chameprosopic	Leptoprosopic	Mesoprosopic	Chameprosopic
Great Russians, Province of Tver	6	84	10	15	81	4
" " " " Riasan	9	73	18	16	72	12
" " " " Koursk	4	75	21	17	71	12
" " " " Erivan	7	76	17	18	74	8
Average, Great Russians	6	77	17	16	75	9
Ukrainians, Province of Kiev	11	74	15	18	75	7
" " " Ekaterinoslav	11	78	11	18	75	7
" " " Tauride	12	75	13	18	75	7
Average, Ukrainians	11	76	13	18	75	7
White Russians, Province of Minsk	7	80	13	16	76	8
Armenians, Province of Erivan	5	63	32	9	68	23
Georgians	6	63	31	11	64	25
Tartars, Crimea						
Zyrian, Province of Oust-Dvinsk	3	64	33	7	72	21
Permiak, Province of Perm	6	57	37	13	60	27
Bashkir, Province of Orenburg	2	54	44	7	62	31
Kalmuck, Province of Astrakhan		55	45	8	58	34
Kirghiz	1	60	39	6	63	31

In a majority of the individuals examined the height of nose did not change or decreased but slightly (from 1 to 2 mm.). The width of the

nose underwent a greater decrease; consequently, the nasal index decreased (Tables 13 and 14). The result of these changes was an increase in the direction of leptorhiny.

TABLE XIII—NASAL INDEX

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	69.67	67.18	72.84	70.36
" " " " Riasan	69.75	68.12	72.24	70.45
" " " " Koursk	71.77	68.24	74.36	72.82
" " " " Erivan	72.12	69.87	73.45	70.58
Average, Great Russians	79.69	68.36	73.13	71.01
Ukrainians, Province of Kiev	73.18	70.96	73.55	71.10
" " " Ekaterinoslav	72.25	71.50	72.88	71.04
" " " Tauride	70.67	69.62	73.18	71.88
Average, Ukrainians	71.93	70.57	73.21	71.47
White Russians, Province of Minsk	69.72	67.06	72.12	70.36
Armenians, Province of Erivan	66.28	65.44	66.73	64.85
Georgians, Province of Tiflis	64.50	63.96	63.20	61.73
Tartars, Crimea	68.12	66.58		
Zyrian, Province of Oust-Dvinsk	65.72	63.85	65.84	64.10
Permiak, Province of Perm	64.87	62.26	65.35	64.22
Bashkir, Province of Orenburg	68.92	66.54	69.18	67.66
Kalmuck, Province of Astrakhan	73.78	72.15	74.60	73.18
Kirghiz	72.81	70.36	73.33	71.78

TABLE XIV—NASAL INDEX

	Males					
	Before the Famine			After the Famine		
	Leptorhin under 70.0 %	Mesorhin 70.01–85.00 %	Platyrhin 85.01 and over %	Leptorhin %	Mesorhin %	Platyrhin %
Great Russians, Province of Tver	59	36	5	66	33	1
" " " " Riasan	64	30	6	66	30	4
" " " " Koursk	76	19	5	76	22	2
" " " " Erivan	60	31	9	74	23	3
Average, Great Russians	65	29	6	71	27	2
Ukrainians, Province of Kiev	59	35	6	63	35	2
" " " Ekaterinoslav	58	39	3	64	36	
" " " Tauride	60	37	3	64	36	
Average, Ukrainians	59	37	4	64	35	1
White Russians, Province of Minsk	53	44	3	62	37	1
Armenians, Province of Erivan	67	29	4	74	25	1
Georgians, Province of Tiflis	91	9		93	7	
Tartars, Crimea	80	18	2	86	14	
Zyrian, Province of Oust-Dvinsk	63	29	8	70	27	3
Permiak, Province of Perm	68	29	3	73	26	1
Bashkir, Province of Orenburg	54	38	8	61	35	4
Kalmuck, Province of Astrakhan	49	37	14	57	34	9
Kirghiz	55	36	9	62	32	6

TABLE XIV—NASAL INDEX (Continued)

	Females					
	Before the Famine			After the Famine		
	% Leptorhin	% Mesorhin	% Platyrhin	% Leptorhin	% Mesorhin	% Platyrhin
Great Russians, Province of Tver	46	50	4	58	42	
" " " " Riasan	71	26	3	72	23	
" " " " Koursk	63	35	2	71	29	
" " " " Erivan	69	29	2	74	26	
Average, Great Russians	62	35	3	69	31	
Ukrainians, Province of Kiev	65	33	2	73	27	
" " " Ekaterinoslav	71	27	2	80	20	
" " " Tauride	63	35	2	71	29	
Average, Ukrainians	66	32	2	75	25	
White Russians, Province of Minsk	55	43	2	64	36	
Armenians, Province of Erivan	60	37	3	68	31	1
Georgians, Province of Tiflis	91	8	1	94	6	
Tartars, Crimea						
Zyrian, Province of Oust-Dvinsk	68	30	2	74	25	1
Permiaks, Province of Perm	71	28	1	75	25	
Bashkir, Province of Orenburg	58	38	4	66	32	2
Kalmuck, Province of Astrakhan	53	35	12	61	32	7
Kirghiz	56	41	3	64	35	1

TRUNK AND THORAX

The length of the trunk, from the jugular incisura to the pubic symphysis, was measured only in males. The absolute, as well as the relative length of the trunk (Table 15) diminished considerably under the influence of *fasting in all the groups. Among the Tartars of Crimea*, this diminution of the length of the trunk was most marked (from 5.4 to 4.9 cm., or from 32.72 to 31.33 per cent in relation to stature). Among the Great Russians and Ukrainians a considerable diminution of the length of the trunk was also found (3.2 cm. on the average). The White Russians showed an average diminution of 2.5 cm. Approximately the same decrease was found in the Armenians and Gruzins (2.6 cm.), and in the Kalmuck and Kirghiz (3.3 cm.).

TABLE XV—LENGTH OF TRUNK (Males)

	Before the Famine		After the Famine	
	Absolute	Relative	Absolute	Relative
Great Russians, Province of Tver	523	31.28	466	30.00
" " " " Riasan	518	31.51	494	30.84
" " " " Koursk	514	31.04	488	30.23
" " " " Erivan	521	31.27	481	27.77

	Before the Famine Absolute	Relative	After the Famine Absolute	Relative
Average, Great Russians	520	31.34	489	30.27
Ukrainians, Province of Kiev	522	31.54	480	30.24
" " " Ekaterinoslav	526	31.61	492	30.41
" " " Tauride	516	31.12	490	30.21
Average, Ukrainians	521	31.42	489	30.26
White Russians, Province of Minsk	533	32.07	508	31.43
Armenians, Province of Erivan	544	32.55	518	31.72
Georgians, Province of Tiflis	522	31.58	496	30.78
Tartars, Crimea	538	32.72	496	31.33
Zyrian, Province of Oust-Dvinsk	533	32.78	502	31.81
Permiak, Province of Perm	538	33.10	504	32.20
Bashkir, Province of Orenburg	535	32.56	511	32.04
Kalmuck, Province of Astrakhan	541	33.15	508	32.15
Kirghiz	536	32.48	503	31.32

Table XVI—Thoracic Circumference (Males)

	Before the[1] Famine	After the Famine	Before the[2] Famine	After the Famine
Great Russians, Province of Tver	53.36	50.84	17	42
" " " " Riasan	53.24	50.52	11	29
" " " " Koursk	52.98	50.12	16	33
" " " " Erivan	52.72	50.33	15	49
Great Russians, Average	53.09	50.51	14	38
Ukrainians, Province of Kiev	53.33	51.42	20	40
" " " Ekaterinoslav	53.67	51.85	21	39
" " " Tauride	53.26	50.86	22	37
Average, Ukrainians	53.39	51.24	21	38
White Russians, Province of Minsk	52.16	50.25	18	44
Armenians, Province of Erivan	53.74	50.27	5	29
Georgians, Province of Tiflis	53.75	51.33	9	33
Tartars, Crimea	52.00	50.34	17	31
Zyrian, Province of Oust-Dvinsk	52.12	50.08	11	36
Permiak, Province of Perm	51.21	50.12	8	33
Bashkir, Province of Orenburg	54.28	51.98	9	35
Kalmuck, Province of Astrakhan	54.36	51.74	6	27
Kirghiz	53.52	51.45	13	41

1. The relation of the thoracic perimeter to the length of the body in % (average).
2. The perimeter of the thorax, less than half the length of the body in %.

The thoracic circumference (Table 16) suffered also considerable diminution. Among the Great Russians and Ukrainians this was more marked than among the White Russians. The greatest decrease was among the Armenians, the smallest among the Tartars of Crimea, whose stature, as previously stated, showed on the contrary the greatest diminution. The number of individuals with an insufficiently developed thorax (circumference less than half the length of the body) was large among all the ethnic groups and in some it was over 40 per cent of the

individuals examined (Great Russians, of Tver Province, 42; Great Russians of Erivan Province, 49; White Russians, 44 and Kirghiz, 41 per cent). Individuals with sub-developed chests were found to be in the majority in the fair group; they were less numerous among persons of a dark or mixed type.

EXTREMITIES

Table 17 shows the modification in the length of arm, measured from the acromion to the point of the medius. Comparing the length of the superior extremities in our men and women, we note that in all the groups the arms of the males are longer than those of the females both before, and after the period of famine. Under the influence of fasting, the superior extremities of males and females become longer with relation to the stature (due to diminution in the latter): among the Great Russians, Ukrainians, and White Russians, this was greater among females, but the inverse was observed in all the other groups:—the superior extremities of males lengthened (relatively) more than those of females. With the Permiak and Bashkir that lengthening took place in the same measure among both sexes. It is important to note that the sexual difference in the relative length of the arms diminished with the Russians while with the other groups it became greater, with the exception of the Permiak and Bashkir, with whom, as we have noted, there was no variation.

Table XVII Length of Arms[1]

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	45.86	46.92	43.52	44.75
" " " " Riasan	46.18	46.75	44.25	44.92
" " " " Koursk	45.36	46.18	43.38	44.56
" " " " Erivan	45.54	46.64	43.44	44.67
Average, Great Russians	45.80	46.60	43.71	44.74
Ukrainians, Province of Kiev	45.92	46.57	43.84	44.88
" " " Ekaterinoslav	45.66	46.78	43.32	44.64
" " " Tauride	45.78	46.84	43.56	44.82
Average, Ukrainians	45.79	46.73	43.58	44.79
White Russians, Province of Minsk	45.08	46.14	42.92	44.18
Armenians, Province of Erivan	45.76	46.65	44.12	44.78
Georgians, Province of Tiflis	45.54	46.73	43.38	44.17
Tartars, Crimea	45.82	46.67		
Zyrian, Province of Oust-Dvinsk	44.28	45.80	42.74	43.56
Permiak, Province of Perm	44.84	45.76	42.91	43.87
Bashkir, Province of Orenburg	45.00	46.17	43.18	44.36
Kalmuck, Province of Astrakhan	44.50	46.12	42.81	44.08
Kirghiz	44.80	46.33	43.33	44.52

[1]With relation to stature in %.

TABLE XVIII—LENGTH OF LEGS[1]

	Males		Females	
	Before the Famine	After the Famine	Before the Famine	After the Famine
Great Russians, Province of Tver	51.24	52.48	51.18	52.52
" " " " Riasan	51.75	53.18	51.62	53.22
" " " " Koursk	51.36	52.72	51.54	52.84
" " " " Erivan	51.22	52.64	51.27	52.75
Average, Great Russians	51.39	52.79	51.43	52.87
Ukrainians, Province of Kiev	51.76	52.64	52.86	53.48
" " " Ekaterinoslav	51.80	52.96	51.68	52.86
" " " Tauride	52.14	53.18	52.24	53.34
Average, Ukrainians	51.92	52.94	52.28	53.27
White Russians, Province of Minsk	51.58	52.66	51.84	53.04
Armenians, Province of Erivan	50.65	51.78	51.24	52.78
Georgians, Province of Tiflis	51.18	52.36	51.26	52.88
Tartars, Crimea	51.68	53.14		
Zyrian, Province of Oust-Dvinsk	52.16	53.10	52.42	53.36
Permiak, Province of Perm	51.85	53.12	52.66	53.42
Bashkir, Province of Orenburg	50.36	51.72	50.48	52.25
Kalmuck, Province of Astrakhan	50.50	51.48	50.84	52.14
Kirghiz	51.10	52.23	51.35	52.66

[1]With relation to stature in %.

The length of the inferior extremity was measured from the great trochanter to the ground. Table 18 shows that the length of the inferior extremities increased with relation to the stature (again diminution of stature). This was more evident among the Great Russians, Armenians, Gruzins, and Bashkir than among the Ukrainians, White Russians, Zyrian, Permiak, Kalmuck, and Kirghiz. The relative lengthening of the inferior extremity was almost alike in both sexes and in all the ethnic groups.

WEIGHT

Weight is a morphological character which undergoes during man's life the most frequent and greatest variations.[1] Like the stature, weight varies daily, reaching its minimum in the early morning and its maximum at the end of the evening. Beginning with the embryonic stage, weight, as well as stature, do not cease to increase except in certain periods, as for instance the few days after birth. The augmentation continues in general to late adult age, after which the weight varies more or less under

[1]According to Tarassevitch the organism subjected to a state of inanition can adapt itself to a certain degree of fasting by diminishing the quanity of its consumption. The result is a kind of *vita minima* during which the organism becomes impoverished in fat and muscle, and muscle-weak.

the influence of different factors; finally, during old age weight generally diminishes.

According to observations of anthropologists, the weight of civilized peoples is more variable than the weight of uncultured tribes. Women having a smaller stature than men, also weigh less. Among certain groups, however, for instance the Arabs and Turks, the average weight of adult females was found to be greater than that of males. This may be explained by the more sedentary life led by the females which favors the development of adipose tissue.

Among all the Russian groups the weight underwent a considerable diminution (Table 19). Among the individuals examined not a single case was found where the weight had remained stationary. Decrease in weight is the first modification of morphological characters under famine conditions. During the first months of the famine the weight rapidly diminished, reaching its maximum during the third or rarely the

Table XIX—Diminution of Weight

	Males				Females			
	% 1–10	% 11–20	% 21–30	% 31–40	% 1–10	% 11–20	% 21–30	% 31–40
Great Russians, Province of Tver	26	48	22	4	14	66	20	
" " " " Riasan	30	44	24	2	26	44	30	
" " " " Koursk	32	43	27		28	41	31	
" " " " Erivan	24	36	33	7	18	45	34	3
Average, Great Russians	28	43	26	3	22	49	28	1
Ukrainians, Province of Kiev	19	58	23		22	64	14	
" " " Ekaterinoslav	16	54	30		30	46	24	
" " " Tauride	22	66	12		34	52	14	
Average, Ukrainians	19	59	22		29	54	17	
White Russians, Province of Minsk	24	54	20	2	28	56	16	
Armenians, Province of Erivan	18	66	14	2	34	46	20	
Georgians, Province of Tiflis	32	42	24	2	30	52	18	
Tartarx, Crimea	36	46	18					
Zyrian, Province of Oust-Dvinsk	34	48	18		40	52	8	
Permiak, Province of Perm	37	51	12		46	45	9	
Bashkir, Province of Orenburg	39	44	17		43	51	6	
Kalmuck, Province of Astrakhan	31	41	28		38	49	13	
Kirghiz	33	47	20		41	45	14	

fourth half year of the famine period. During the last two half years (fifth and sixth) weight showed only insignificant variations, even in cases where a somewhat increased amount of food was available. The weight of obese individuals diminished more than that of thin individuals The diminution of weight of females was probably more rapid than that of men. Their weight also reached its minimum in a shorter time than that of males. Weight of individuals older than forty years (males and

females) diminished more slowly than the weight of younger individuals.

INDEX OF PIGNET

There are several formulas by means of which one can estimate the physical state of an organism. To this end, the author has employed the index of Pignet. This author proposed the following formula: from the stature, estimated in centimeters, subtract the sum of the thoracic circumference in centimeters and the weight in kilograms. The difference serves to express the physical state of the individual examined, which improves as the difference obtained decreases. Thus a difference under 10 indicates an excellent physical constitution; from 11 to 15, strong; from 16 to 20, well; from 21 to 25, average; from 26 to 30, weak; and from 31 to 35 and above, very weak. Table 20 in which data concerning men only are brought together, shows the degree of weakening of the physical constitution of invididuals who underwent long fasting. In all the groups (excepting the Tartars of Crimea, the Zyrians, and the Permiak), the number of persons with whom the index

TABLE XX—PIGNET'S CONSTITUTIONAL INDEX (MALES)

	Before the Famine						After the Famine					
	Under 10	11–15	16–20	21–25	26–30	31 and above	Under 10	11–15	16–20	21–25	26–30	31 and above
Great Russians, Province of Tver	5	24	36	26	9			16	28	28	22	6
" " " " Riasan	8	25	37	26	4		4	18	32	31	13	2
" " " " Koursk	6	26	32	32	4		2	14	32	34	16	2
" " " " Erivan	7	21	34	23	12	3	4	12	30	23	29	2
Average, Great Russians	7	24	35	26	7	1	2	15	31	29	20	3
Ukrainians, Province of Kiev	5	24	29	28	14		1	12	16	39	27	5
" " " Ekaterinoslav	8	32	26	28	6			21	17	36	22	4
" " " Tauride	6	18	16	42	16	2	4	12	18	36	24	6
Average, Ukrainians	6	24	24	33	12	1	2	15	16	39	24	4
White Russians, Province of Minsk	5	19	31	32	11	2	1	14	22	44	15	4
Armenians, Province of Erivan	13	18	29	37	3		2	11	32	38	12	5
Georgians, Province of Tiflis	8	20	26	33	13		3	18	20	36	23	
Tartars, Crimea		16	32	38	14			12	25	40	15	8
Zyrian, Province of Oust-Dvinsk	2	12	23	44	19			8	19	49	23	1
Permiak, Province of Perm		18	27	45	20			9	24	46	21	
Bashkir, Province of Orenburg	5	21	33	33	8		1	11	23	51	12	2
Kalmuck, Province of Astrakhan	8	24	36	29	3		2	13	27	42	14	2
Kirghiz	7	26	29	31	7			14	26	42	16	2

indicated a physical constitution above the average was found to be 50 per cent, before the famine, and in certain places even reached 70 per cent (Great Russians of the Province of Riasan). After the famine, the

index in all the groups (with the exception of the Great Russians of the Province of Riasan) reached the average in only a minority of the persons examined. With the Ukrainians of the Province of Kiev the number of individuals with an average index fell to 29, with the Zyrian, to 27 per cent. On the contrary the number of persons with a weak physical index (index greater than 25) was considerably augmented in all the groups during the period of famine.

DISCUSSION AND FURTHER OBSERVATIONS

Thus we see that among all the groups observed the morphological characters were considerably modified during the three years' famine. The stature in males was reduced by 3.8 to 6.6 cm., in females by 3.6 to 4.8 cm. The absolute and relative size of the head diminished; the horizontal circumference of the head also decreased. The antero-posterior diameter in a majority of the ethnical groups underwent a perceptibly greater shortening than the transverse diameter. This resulted in the increase of dolichocephalic individuals and the decrease of brachycephals. Only with the Armenians, Gruzins, and Tartars of Crimea, did the cephalic index modify in the opposite direction as a result of a greater shortening of the transverse maximum diameter. The length of the face decreased less than its breadth, which resulted in a modification of the type in the direction of leptoprosopy. In similar manner the length of the nose diminished relatively less than the breadth, the result being an increase in leptorrhiny and decrease in platyrrhiny. The absolute and relative lengths of the trunk decreased. The thoracic circumference diminished considerably, consequently the number of individuals with subnormal chest (thoracic perimeter less than half the stature) was notably larger—in certain ethnic groups more than 40 per cent of the individuals examined. The superior extremities appeared lengthened with relation to the stature, as did the inferior extremities. The body weight in all the groups decreased considerably. Among the individuals examined not one was found whose weight had not diminished; a great number lost 30 per cent of the former weight. Pignet's constitutional index shows that the physical strength decreased in all the groups.

To this we may add that with very emaciated individuals, as my colleagues stated, the hair grew more slowly, fell out prematurely, and tended to rapidly become gray. Growth of the nails on hands and feet was retarded and the teeth readily decayed. The eyes became limpid as with aged people; the skin lost its elasticity and became

wrinkled; the gait became weak and uncertain; the body bent. In a general way—the individual acquired a more or less senile appearance. Most of the subjects examined looked dejected and apathetic. In women menstruation ceased during the period of fasting. The sexual instinct became very weak and even disappeared entirely. The number of births decreased enormously, while on the other hand the number of children either prematurely or still born, monsters, and children with different anomalies, considerably increased.

To these anthropological data we can add the following facts pointed out by Professor Oppel. Under the influence of an irregular diet perforating ulcer of the stomach became a very frequent illness (because of the use of undigestible food); not infrequently simple furuncles were transformed into carbuncles; agnail and abscesses of the nails and hands also became frequent maladies. Also the number of cases of lymphadenitis, ulcer of the leg, and hernia increased. The breaking down of hemorrhoidal knots was frequently observed. "Progressive emaciation under the influence of inanition" writes Oppel, "results in depriving the tissues of the human organism of their natural immunity and of their proper faculties of regeneration."

Without doubt it was not only the morphological aspects that were affected, but profound changes have occurred in the internal organs. As previous investigations have shown, not all the internal organs modify to the same degree under the influence of inanition. "Adipose tissue has been sacrificed in the first place and has almost completely disappeared, then came the muscles and certain organs, as the liver, the pancreas; on the contrary, the heart and central nervous system, organs the role of which is preponderant in preserving life, did undergo hardly any changes." (Tarassevitch).[1]

In discussing inanition we have in mind not only fasting as a result of an insufficient quantity of food, but also qualitative inanition. I think that psychological factors, such as depression and apathy, must also be taken into consideration as the cause of changes in the organism. I am convinced that the psychological factors, if they are of sufficient duration and intensity, may provoke as considerable changes in the morphological characters of man as does simple inanition. Consequently it may be assumed that the morphological aspects of a great part of

[1]More than sixty bodies of children who died of inanition were subjected to autopsy in Kharkov by Dr. Leo Nicolaiev. The results of his investigation will be published soon.

the population of Russia began to be modified during the period of the war and the revolution which preceded the period of famine, under the serious psychological disturbances.

Looking for the causes for emaciation under the influence of inanition, Professor Koltzoff, in his latest work, emphasizes also the important role played by psychological disturbances. "We know very little," he writes on this subject, "of the causes provoking maladies of the glands of internal secretion, but it suffices to remember the morphological role which closely binds each of them with the nervous system in order to become convinced that every deep impression received by the nervous system must reflect on the function of the thyroïd gland, the hypophysis, the suprenal glands, etc., and consequently, disturb the normal equilibrium of the internal exchange."

GENERAL RELATIONS OF SITTING HEIGHT TO STATURE AND OF SITTING HEIGHT AND STATURE TO WEIGHT

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Stature is usually recognized as the most satisfactory general standard with which to compare other linear measurements of the human body. Measurements thus expressed in terms of stature are called either relative measurements or indices. Thus sitting height divided by stature times 100 may be called relative sitting height or the index of sitting height. Since in adults of a given race relative sitting height is known to vary inversely with stature this ratio makes an imperfect racial index. The average relative sitting height of one race may be less than that of another race simply because the average stature of the former race is greater. If groups of individuals of the same stature be selected from each race the relative sitting height of the shorter race may be less than that of the taller race. For making racial, sexual, or similar comparisons an index is needed which takes into account the variations in relative sitting height which characterize variations in stature.

In young adults the sitting height, *Si*, varies approximately as the two-thirds power of the stature, *H*, multiplied by a constant, *K;* $\mathrm{Si} = \mathrm{K\ H}^{2/3}$. The relative sitting height, $\frac{100\ \mathrm{Si}}{\mathrm{H}}$, varies inversely as the cube root of the stature, $\frac{100\ \mathrm{Si\ H}^{1/3}}{\mathrm{H}} = \mathrm{K}$. This constant, determined for a given race, sex, and age period, makes a convenient index of relative sitting height. The following data illustrate the validity of such a constant for this purpose.

Davenport, in 1921, in his study of the anthropological data collected during the medical examinations of war veterans at demobilization gives data on stature and sitting height for 96,239 individuals belonging to the white troops and 6,433 individuals belonging to the negro troops. The mean stature of the white troops was 171.99 cm. The mean sitting height was 90.39 cm. The mean relative sitting height was 52.556.

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The cube root of the stature is 5.561. By multiplying the relative sitting height by the cube root of the stature we get 292.27 as the numerical expression of the constant or racial index of build. In table LXXXIII of the report referred to above are given data on the correlation between stature and sitting height of these troops. From these data the average relative sitting height for each two centimeters of stature may be determined. These determinations are given in the column entitled "observed" in table I. For each stature there has likewise been calculated the relative sitting height based on the formula that $\frac{100 \text{ Si } H^{1/3}}{H} = 292.27.$

TABLE I

To illustrate observed and calculated relative sitting height in United States troops on demobilization:

Stature Cm.	Observed	Relative Sitting Height White troops K - 292.27	Observed	Negro troops K - 282.45
148.5	60.7	55.2	54.4	53.3
150.5	55.7	54.9	54.2	53.1
152.5	54.8	54.7	53.8	52.9
154.5	56.1	54.4	53.3	52.6
156.5	54.2	54.2	52.5	52.4
158.5	53.9	54.0	52.3	52.2
160.5	53.8	53.7	52.1	52.0
162.5	53.5	53.5	51.8	51.8
164.5	53.3	53.3	51.7	51.6
166.5	52.8	53.1	51.4	51.4
168.5	52.9	52.9	51.1	51.2
170.5	52.8	52.7	51.1	51.0
172.5	52.5	52.5	50.8	50.8
174.5	52.4	52.3	50.7	50.6
176.5	52.1	52.1	50.3	50.4
178.5	51.9	51.9	50.1	50.2
180.5	51.8	51.7	49.8	50.0
182.5	51.6	51.5	49.9	49.8
184.5	51.4	51.3	49.8	49.6
186.5	51.0	51.1	49.1	49.4
188.5	50.5	50.9	48.8	49.3
190.5	50.5	50.8	47.8	49.1
192.5	49.7	50.6	47.0	48.9
194.5	48.6	50.4	45.8	48.8
196.5	48.4	50.2		
198.5	47.0	50.1		
200.5	47.1	49.9		
202.5	48.1	49.7		

This table shows a close correspondence between observed and calculated data, except at the extremes. Groups with a stature of 150.5 cm. or less show a greater, those with a stature of 188.5 cm. or more a smaller observed than calculated relative sitting height. In those groups the number of individuals is relatively small and the chances of error in observation are relatively great. The coefficient of correlation for height, sitting height in these troops was 0.6626.

Table I also gives data on the negro troops calculated in a manner similar to that for the white troops. The racial "constant" or index of relative sitting height is here 282.45 or 3.4 per cent less than that for the white troops. Divergences between observed and calculated data similar to those for the white troops are to be seen. The coefficient of correlation for height, sitting height in these troops was 0.6088.

Hitchcock's data, 1900, or 4,000 Amherst students, give an index of 291.9. For 1,105 Wisconsin men students entering the university in 1922 the index was 289.4. In both series observed and calculated data are fairly close except at the extremes. Of the 1,105 Wisconsin students 425 were recorded as having statures at even inches. The mean stature of the latter was 173.35 centimeters, the mean sitting height 90.17 centimeters, the mean relative sitting height 52.01. The index of relative sitting height was 290.0. The slightly lower index for students entering college as compared with men at demobilization is probably to be ascribed partly to age. In part it may possibly be ascribed to the effects of military training on the latter group or to methods of measuring. The following table shows the number of individuals for each inch of stature, the relative sitting height, the coefficient of variation in sitting height for the individuals within the larger sub-groups and the relative sitting height calculated from the index of relative sitting height given above. The calculated data correspond closely with the observed.

Table II

To show the mean sitting height observed in University of Wisconsin students of a given stature, the coefficient of variation, and the sitting height calculated from the formula, $\frac{100\ \mathrm{Si}}{\mathrm{H}^{2/3}} = 290.0$.

Stature Inches	Stature Cm.	No. Indiv.	Mean Sitting Ht. Centimeters	Coefficient of Variation per cent	Calculated Sitting Height
57	144.8	1	80.0		79.9
59	149.9	1	81.3		81.8
60	152.4	1	85.1		82.7
61	154.9	2	83.8		83.7
62	157.5	2	85.1		84.6

Stature Inches	Cm.	No. Indiv.	Mean Sitting Ht. Centimeters	Coefficient of Variation per cent	Calculated Sitting Height
63	160.0	10	84.1	3.58	85.4
64	162.6	21	85.8	3.63	86.3
65	165.1	29	86.5	3.05	87.2
66	167.6	52	87.9	3.57	88.1
67	170.2	48	88.6	3.46	89.0
68	172.7	67	89.7	2.76	89.9
69	175.3	70	91.2	3.00	90.8
70	177.8	48	92.5	3.43	91.6
71	180.3	34	92.7	2.22	92.5
72	182.9	21	94.0	2.15	93.4
73	185.4	13	93.7	3.13	94.2
74	188.0	2	94.7		95.1
75	190.5	2	96.3		96.0
76	193.0	1	96.5		96.9

The variability in sitting height for a given stature corresponds well with that shown in Davenport's data on U. S. troops at demobilization. For white troops of stature 172.5 cm. this was 2.95 per cent. On the other hand taking sitting height into consideration irrespective of stature Davenport's data show less variability than those on Wisconsin students. The coefficient of variation for the former is 3.88 per cent, for the latter 4.12 per cent. The coefficient of variation in stature is less for the Wisconsin students, 3.58 per cent, than for the white troops at demobilization, 3.87 per cent.

The data on measurements of college women tabulated by Mrs. Anne Barr Clapp at the University of Nebraska and reproduced in Seaver's Anthropometry, 1909, page 97, give an opportunity to test out the relative sitting height index as applied to young American women. The central group here is 160 cm. tall. The average sitting height given for this group is 85.1 cm. The relative sitting height is therefore 53.19. The index of relative sitting height is 288.76. The observed and calculated relative sitting heights for each centimeter of stature are as follows:

Table III

To illustrate the observed and calculated relative sitting height in women college students. Based on data tabulated by Mrs. Clapp at the University of Nebraska.

Stature	Relative Sitting Height Observed	Calculated	Stature	Relative Sitting Height Observed	Calculated
160	53.2	53.2	173	52	51.8
159	53.5	53.3	172	52.2	51.9
158	53.5	53.4	171	52.3	52.0
157	53.4	53.5	170	52.1	52.1
156	53.4	53.6	169	52.3	52.2

Stature	Relative Sitting Height Observed	Calculated	Stature	Relative Sitting Height Observed	Calculated
155	53.6	53.8	168	52.6	52.3
154	53.8	53.9	167	52.8	52.4
153	53.9	54.0	166	52.9	52.5
152	54.0	54.1	165	52.8	52.6
151	54.4	54.2	164	52.7	52.8
150	54.5	54.3	163	52.7	52.9
149	54.6	54.5	162	52.7	53.0
			161	52.9	53.1

This table shows that the observed and calculated values are closely similar, especially when the fact is taken into consideration that the Nebraska observations are based on a relatively limited number of individuals (1,500).

The mean stature of 1,045 girls who entered the University of Wisconsin in September, 1922 was 161.57 centimeters. The mean sitting height was 85.6 centimeters. The mean relative sitting height based on these figures was 52.98 per cent. The index of relative sitting height was 288.55, approximately the same as the index base on the Clapp data which was 288.76.

The following table shows the mean sitting height observed for each quarter inch, 6.35 mm. of stature, the number of individuals in the group and the sitting height calculated from the formula: 100 sitting height = height $^{2/3}$ times 288.55.

TABLE IV

To show the mean sitting height observed in 1045 University of Wisconsin girl students of a given stature, and the sitting height calculated from the formula given in the text:

Stature Cm.	Number of Individuals	Mean Sitting Height Cm.	Calculated Sitting Ht. Cm.	Stature Cm.	Number of Individuals	Mean Sitting Height Cm.	Calculated Sitting Ht. Cm.
141.0	1	69.3	78.3	162.6	58	85.9	85.9
146.1	2	81.3	80.1	163.2	34	86.4	86.1
147.3	2	78.7	80.4	163.8	46	86.5	86.4
148.0	1	81.3	80.6	164.5	38	87.1	86.6
148.6	5	81.0	80.8	165.1	46	86.6	86.8
149.2	4	82.0	81.0	165.7	29	87.1	87.1
149.9	8	80.8	81.3	166.4	26	86.6	87.3
150.5	1	82.0	81.5	167.0	23	87.9	87.5
151.1	11	81.8	81.7	167.6	42	88.1	87.7
151.8	3	80.5	82.0	168.3	14	88.4	88.0
152.4	23	81.8	82.2	168.9	13	88.4	88.2
153.0	10	83.3	82.4	169.5	14	88.6	88.4
153.7	21	82.5	82.7	170.2	20	88.6	88.7
154.3	15	82.8	82.9	170.8	9	89.9	88.9
154.9	31	83.6	83.1	171.5	9	90.2	89.1
155.6	27	84.0	83.4	172.1	7	89.9	89.4

Stature Cm.	Number of Individuals	Mean Sitting Height Cm.	Calculated Sitting Ht. Cm.	Stature Cm.	Number of Individuals	Mean Sitting Height Cm.	Calculated Sitting Ht. Cm.
156.2	40	83.1	83.6	172.7	6	89.7	89.6
156.8	25	83.8	83.8	173.4	7	90.2	89.8
157.5	55	83.6	84.1	174.0	9	90.7	90.1
158.1	18	83.8	84.3	174.6	3	91.4	90.3
158.8	45	84.3	84.5	175.3	7	89.4	90.5
159.4	39	85.0	84.7	175.9	2	92.4	90.7
160.0	65	85.0	85.0	176.5	2	90.4	91.0
160.7	33	85.1	85.2	177.2	1	91.4	91.2
161.3	48	85.8	85.4	180.3	1	91.4	92.4
161.9	44	85.9	85.7	182.2	1	94.0	93.1
				182.9	1	91.4	93.3

This table shows a good correspondence between observed and calculated values if the small number of individuals in each sub-group is taken into consideration. In stature the women students show about the same variability as the men students. For the former the coefficient of variation was 3.58 per cent, for the latter 3.55 per cent. On the other hand the women students show less variability in sitting height than the men. For the latter the coefficient of variation was 4.12 per cent while it was only 3.46 per cent for the women. For the men, as shown in table 2, the coefficient of variation in sitting height for the even stature groups averaged about 3.10 per cent, while for the women it averaged about 2.30 per cent as shown in the following table:

TABLE V

The coefficient of variation in sitting height found at even stature groups in University of Wisconsin women students.

Stature Inches	Stature Cm.	Coefficient of Variation per cent	Stature Inches	Stature Cm.	Coefficient of Variation per cent
59	149.9	2.51	65	165.1	2.21
60	152.4	2.47	66	167.6	2.21
61	154.9	2.21	67	170.2	2.76
62	157.5	2.35	68	172.7	2.61
63	160.0	1.80	69	175.3	2.17
64	162.6	2.07			

The illustrations given indicate the value of the index of relative sitting height in studying racial and sexual characteristics involving sitting height. In making use of such an index corresponding age groups should be compared.

Rood Taylor has placed at the Wistar Institute detailed measurements on about 250 new-born infants. These data show an index of relative

sitting height of 248.9 for white male infants, one of 249.8 for white female infants. The correspondence between calculated and observed relative sitting heights for stature groups is much less than that shown above for stature groups in young adults. It is closer for boys than for girls. Noback's formula, 1922,[1] for estimating sitting height in foetuses gives a closer fit for the new born girls but not so close a fit for the new born boys. For childhood the available data do not indicate that the index under consideration is of great value. The alterations in relative sitting height due to growth factors make advisable the use of some other index.[2] The chief usefulness of the index comes into play in dealing with adults. The data of Weissenberg, 1911, on South Russian Jews indicate that the index increases from infancy to about the age of seventeen in women and twenty-one in men, and then remains relatively stationary until old age commences when the index declines.

In the following table are shown the indices for relative sitting height for age groups for which data are given by Weissenberg and for Washington, D. C. school children for which data were furnished by MacDonald in 1897–8.

TABLE VI

Indices of relative sitting height for age groups based on data from Weissenberg, 1911, and MacDonald, 1898:

Age in Years	Weissenberg		MacDonald White		MacDonald Negro	
	Male	Female	Male	Female	Male	Female
0	246.3	245.3				
2	264.4	260.3				
3	263.8	259.1				
4	264.4	261.2				
5	265.5	264.9				
6	266.9	264.6	268.7	264.4	262.4	260.7
7	267.6	267.4	266.9	265.6	262.7	260.3
8	268.6	266.3	269.7	265.2	262.8	260.6
9	268.2	267.0	268.5	266.8	265.6	262.1
10	269.1	270.6	266.9	267.0	262.3	263.2
11	267.0	270.0	269.4	268.2	263.7	264.9
12	268.1	273.3	271.0	271.6	267.6	265.3
13	270.4	275.5	272.1	274.5	265.3	266.9

[1]Crown rump length $= \frac{2}{3}$ crown heel length $+ 3$mm.

[2]The following formulae seem best to fit available data in American children:

Relative sitting height, $\frac{100\ \mathrm{Si}}{\mathrm{H}} =$

$$\text{Girls } 52.1 + .004432\ (\mathrm{H}-147)^{1.8}$$

$$\text{Boys } 51.4 + .00374\ (\mathrm{H}-160)^{1.8}$$

H = Stature in centimeters.

Age in Years	Male	Female	White Male	White Female	Negro Male	Negro Female
14	270.7	279.5	274.3	279.2	267.7	270.7
15	273.2	285.1	276.7	281.9	267.9	273.6
16	278.9	286.1	281.0	284.8	268.9	276.8
17	284.8	288.4	284.5	284.3	275.9	277.4
18	286.6	288.2	288.8	285.3		280.1
19	287.2	287.2		287.6		286.8
20	287.6	289.4				
21—25	289.0	287.8				
26—30	290.0	288.1				
31—40	288.1	286.4				
41—50	290.3	286.9				
51—60	289.9	284.0				
61—75	287.3	279.8				

This table shows that the index is larger for girls than for boys from 10 to 17–18 years of age and is larger for whites than for blacks at all ages. The difference between the races is more marked after puberty than before. The 19 year old group of colored girls is an anomalous group. Under negroes are included all children with observable negro blood. The "negroes" contain therefore much white blood.

For the racial groups of troops at demobilization the data on pages 117 and 193 of the army statistics referred to above yield the following results:

Table VII

Race	No. of indiv.	Mean stature	Rel. Sitting height	Index of rel. Sitting height
White	96,239	171.99	52.56	292.3
Indians	105	171.51	52.53	291.9
Chinese	22	171.11	52.04	288.9
Japanese	32	170.94	51.41	285.3
Negro	6,433	171.97	50.79	282.5

From the data on pages 113 and 191 the following results are obtained as to the index of relative sitting height in troops belonging to the various subdivisions of the white race.

Table VIII

Race	No. of Indiv.	Mean stature cm.	Rel. sitting height	Index of rel. sitting height
French	1455	168.59	53.07	293.2
Irish	6137	171.36	52.79	293.3
English	4199	172.08	52.67	293.0
Scotch	2074	172.54	52.60	292.8
German	7051	172.04	52.52	292.1
Polish	2404	169.41	52.78	292.0
Italian	3506	165.18	53.13	291.5
Hebrew	1684	166.91	52.76	290.4

The Poles, Italians and Hebrews in this list all have a high relative sitting height, but a slightly low index of relative sitting height.

Bean, 1922, has recently given a summary of data relating to sitting height in various races. His data on Americans of European descent give indices of relative sitting height which correspond well with those given above. They may be summarized as follows:

TABLE IX

Indices of relative sitting height in Americans of European descent based on data from Bean, 1922.

Group	No. of individuals	Average stature	Relative sitting ht.	Index of rel. sitting ht.
Camp Lee	610	172.4	52.7	293.3
Camp Gordon	523	174.8	52.3	292.4
Motor Truck Camp	444	174.1	52.3	291.9
University Group	489	173.8	52.0	290.2
Gen. Average	2066	174.0	52.4	292.5

WHITES

We have seen above that the index of relative sitting height for the white troops at demobilization was 292.3. For men of various European groups belonging to these troops the index varied from 290.4 for Hebrews to 293.3 for the Irish. Bean, 1922, gives an average stature of 165 cm., an average relative sitting height of 52.5 for 165,000 "European men;" an average stature of 155 cm., an average relative sitting height of 53.5 for 1,500 women. The corresponding indices are 288 and 287.4

The following table based largely on data cited by Bean, 1922, gives a summary of the indices of various European groups:

TABLE X—EUROPEAN GROUPS

Group	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Spanish	Giuffrida Ruggeri	119,571 M.	164.0*	52.1	285.0
French	Bertillon	2,695 M. 26—44 yr.	164.3	53.4	292.4
French	Manouvrier	130 F. 24—45 yr.	154.5	54.2	290.7
French	Collignon	280 M.	165.6	52 4	287.8
Mediterranean		30 M.	163.6	52.7	288.2
Celts		100 M.	164.0	52.5	287.3
Kymris		100 M.	166.0	52.3	287.4
Lorrains		50 M.	169.6	52.2	288.9

Group	Investigator	Number of individuals	Mean statue	Relative sitting ht.	Index of rel. sitting ht.
Paris, insane	MacAuliffe	100 M.	165.0	51.7	283.5
Paris, normal	"	100 M.	165.1	52.7	289.1
Normandy	Garnier Moronval	100 M.	168.1	52.3	289.6
Italians (Bologna)	Riccardi	M. 30—40 yr.	169.1	52.0	287.6
		F. 30—40 yr.	155.2	53.2	286.0
Baden	Ammon	men	165.2	52.3	287.0
Rural	"	boys	167.8	52.7	290.7
Urban	"	boys	169.7	51.9	287.3
Eingewanderte	"	boys	170.3	52.6	291.6
Little Russians	Diebold	200 M.	166.9	51.4	283.0
English	Galton	men	169.8	53.1	293.0
"	"	men	172.5	53.0	295.0
"	"	women	158.3	53.6	289.9
Lithuanians	Walber	60 M.	170.5	51.9	287.8
Swedes	Retzius and Furst	45,688 M.	170.9	52.9	294.1
Norwegians	Martin	men	172.1	53.0	294.8

*Stature estimated

The following table is based upon data furnished by Pittard in his valuable study of several Balkan groups:

TABLE XI—BALKAN GROUPS

Males

Group	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Gypsies	780	164.9	52.6	285.7
Tartars	215	165.7	53.0	291.1
	100	160.5	53.3	289.7
	100	169.0	53.0	293.0
	15	177.3	51.6	289.9
Gagaouz	41	166.4	53.4	291.5
Roumanians	175	167.0	52.9	291.5
Greeks	125	167.4	52.5	289.3
Lazes	152	167.5	52.6	290.0
	Females			
Roumanians	19	152.9	54.0	288.8
Tartars	38	154.9	53.5	287.3
Gagaouz	13	154.4	53.9	289.4

For Armenians and Kurds we have the following data on males:

TABLE XII

Group	Investigator	Group	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Armenians	Pittard	125	166.1	53.6	294.6
Armenians	Tvarjanovic	105	167.1	54.2	298.5
Kurds	Pittard	63	170.0	51.8	286.7

For South India E. Schmidt has furnished data on stature and sitting height of a number of groups. Some of these have been utilized in preparing the following table.

TABLE XIII—NATIVES OF SOUTH INDIA

Group	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Better social Groups				
Brahmans	17	162.6	51.8	282.7
Badaga	28	163.9	51.3	280.2
Wellala	23	163.9	52.0	284.6
Sudra	23	165.9	52.1	285.7
Schaner	20	166.2	51.2	281.5
Toda	22	169.0	51.6	285.2
Lower groups				
Pulayer	8	157.8	51.6	278.8
Kota	21	159.8	52.3	283.3
Pariah	28	162.5	51.5	280.9
Primitive groups				
Ulladen	5	151.5	51.8	276.1
Malānayer	13	153.1	52.2	279.3
Kanikar	10	153.6	51.2	273.9
Irular	14	155.4	51.9	279.0
Kurumbar	30	156.3	51.6	277.7
Mala Araa	20	158.0	52.2	282.3
Malser	27	162.1	50.8	279.0

In general the lower social classes have a lower index than the better social classes. The relatively low position of the most favored cast, the Brahmans, may be due to the fact that Schmidt had to get most of his data from those confined in jail. The most primitive groups have the lowest index. Certain of these groups are classed by some investigators as pre-Dravidian along with the Australians, Sakai and other groups. From the standpoint of relative sitting height they resemble the Sakai but they have a higher index of relative sitting height than the Australians as may be seen in the folowing table:

TABLE XIV—AUSTRALIANS, SAKAI AND SINGALESE

Group	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Australians	Spencer and Gillan	19 M.	166.4	46.8	257.4
		21 M.	172.4	44.3	246.6
		10 F.	156.8	48.4	261.0
		17 F.	159.1	47.6	257.9
Sakai	Duckworth	5 M.	149.1	49.7	263.5
	Annandale and Robinson	26 M.	152.3	52.8	282.0
	Knocker	13 M.	156.3	52.2	281.1
		4 F.	144.3	52.8	276.9
Singalese	Deschamps	16 M.	160.5	48.6	264.1

From the standpoint of relative sitting height the primitive groups of South India more nearly resemble the negroes and negritoes than the Australians.

NEGROES AND NEGROIDS

The index of relative sitting height of 6,433 negro troops at demobilization was 282.5. For one group of 583 American male negroes Bean, 1922, gives a mean stature of 169.7 cm. and a relative sitting height of 51.0, for another group of average stature of 172.9 cm., a relative sitting height of 50.5. For the first group the index is 282.4, for the second group 281.3. There are no extensive data on the relative sitting height of adult American negresses. The following data from MacDonald 1897–8 indicate an index slightly lower for women than for men. The "age 19" group is an anomalous group.

Table XV—American Negresses

Age	Number	Mean Stature	Relative sitting ht.	Index of rel. sitting ht.
18	54	158.17	51.8	280.14
19	20	159.33	52.9	286.78
19.6—29.9	9	153.5	52.1	279.00

The indices of American negroes are higher than for the African and Oceanic negroes and indicate either the influence of white blood or the effect of environment or both factors.

For 3,500 "Africans" Bean gives as a general average for males a stature of 172 cm. and a relative sitting height of 49.5; for 100 females a stature of 162 cm. and a relative siting height of 49.4. The corresponding indices are male 275.3, female 269.3.

The following table shows indices of relative sitting height for Nigerian and West African negroes, based on data cited by Bean from Tremearne Verneau and Ruelle:

Table XVI—African Negroes

Males

Tribe	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Nigerian	Tremearne	119	159.4	50.8	275.4
Ba Teké	Poutrin	25	162.1	50.7	276.4
Bondjio	Poutrin	18	163.0	50.6	276.4
M'Baka	Poutrin	44	167.1	50.4	277.6
Amboras	Verneau	82	168.6	50.1	276.8
W. African	Verneau	111	170.0	50.4	279.0
Nigerian	Tremearne	152	170.5	50.5	280.0

Tribe	Investigator	Males Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Mongawa	Gaillard & Poutrin	25	171.0	47.9	275.9
Nigerian	Ruelle	739	172.1	48.5	269.8
"	Tremearne	37	172.1	49.2	273.7
"	"	142	173.0	49.8	277.5
Kouri	Gaillard & Poutrin	30	173.0	48.4	269.7
Bondamme	Gaillard & Poutrin	105	173.0	49.2	274.1
Nigerian	Tremearne	116	176.0	49.2	275.7
Dahomey	Verneau	41	176.3	49.4	277.0
Nigerian	Tremearne	141	177.2	47.4	266.2
"	"	140	184.0	49.3	280.4
"	Verneau	6	187.1	47.0	268.8
		Females			
Central Africa	Poutrin	54	155.7	50.8	273.3
West Africa	Verneau	10	158.3	50.5	273.2

The Bushman have indices of relative sitting height similar to those of the taller negroes as shown in the following table:

TABLE XVII—BUSHMAN

Investigator	Males Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Seiner	13	152.5	52.1	278.4
Werner	14	155.3	49.5	266.1
Seiner	72	156.4	51.0	274.8
Average				274.0
	Females			
Seiner	18	148.2	51.0	269.9
Werner	17	149.7	50.5	268.0

PIGMIES

On the other hand the pigmies have a much higher index of relative sitting height as may be seen in the following table based on data from Poutrin cited by Bean:

TABLE XVIII

Group	Male No. of individuals	Average stature	Relative sitting ht.	Index of rel. sitting ht.
N'Gali	8	148.0	55.5	293.6
Labaye	9	148.6	54.3	286.7
Ouesso	4	151.2	53.3	284.0
N'Gongo	4	154.0	52.0	278.7
M'Bio	12	155.1	53.2	285.6
Gondicola	12	158.4	52.8	285.8
	Female			
Labaye	7	143.5	53.1	278.0
N'Gali	5	144.3	53.3	279.6
M'Bio	4	154.7	51.5	276.5

In general African groups supposed to have a large or a predominating Hamitic or Semitic inheritance show a lower stature and a higher index of relative sitting height than the true negroes, but this is not always the case as shown in the following table based on data cited by Bean:

Table XIX—Hamites and Mixed Groups

Group	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
		Males			
Toureg Vassals	Verneau	6	158.5	48.8	264.0
Soudanese	Hagen	10	160.8	52.7	286.5
Soudanese	Hagen	10	161.8	52.9	288.3
Kharga Oasis (Egypt)	Hrdlička	150	163.4	51.3	280.5
Berbers	Topinard	67	164.3	51.7	283.2
Somali	Puccioni	25	165.5	50.8	278.8
Kaffirs	Suk	54	166.2	51.4	282.6
Kanembu	Gaillard & Poutrin	95	167.6	49.0	270.2
Oulad-Shinon	Gaillard & Poutrin	55	169.3	49.1	271.6
Teda	Gaillard & Poutrin	33	169.6	49.6	274.6
Toureg	Verneau	19	172.1	48.8	271.8
Toureg nobles	Verneau	36	175.1	49.2	275.2
Bulala	Couvy	85	175.2	47.4	265.2
		Females			
Kaffirs	Suk	44	161.0	51.4	279.6

The distribution according to stature of the 150 inhabitants of the Kharago Oasis studied by Hrdlička is as follows:

Table XX

Number	Mean Stature	Relative sitting ht.	Index of rel. sitting ht.
14	154.8	51.7	277.6
23	158.8	51.3	277.8
24	161.3	51.5	280.3
25	163.8	51.7	283.0
30	166.3	50.9	280.1
21	168.8	51.0	281.9
13	172.4	49.4	281.6

If we turn now to the Oceanic negroes we find that the Papuans have an index of relative sitting height similar to that of the African negroes, the negritoes of the Philippines have a lower index and the Melanesians a larger index. This may be seen in the following table based on data cited by Bean.

TABLE XXI

Males

Group	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Papuans	Garrett	6	153.6	51.0	272.4
	Schellong	32	160.6	51.4	279.4
	Schellong	15	160.9	50.4	274.1
	Hagen	14	162.8	50.0	273.0
	Chalmers	20	163.6	49.3	271.4
	Chalmers	19	165.6	49.2	270.2
	Spencer & Gillen	16	167.7	49.9	278.6
	Chalmers	16	170.2	49.5	274.3
	Average				274.8
Negritoes of Philippines	Newton	231	146.8	50.6	266.9
Melanesians	Hagen	9	161.7	51.4	280.0
	"	11	161.7	52.0	283.3
	"	13	163.3	51.4	280.9
		Females			
Negritoes of Philippines	Newton	120	138.8	51.2	265.1

AMERICAN INDIANS

For the 105 Indians included in the demobilization statistics cited above the index of relative sitting height was 291.9. For 1,050 American Indians Bean, 1922, gives for males an average stature of 168 cm. and a relative sitting height of 52.3; for 500 females an average stature of 157 cm. and a relative sitting height of 52.6. These figures give an index of relative sitting height of 288.6 for males, of 283.8 for females. The indices for the tribes cited by Bean for which averages are based on 25 or more individuals of a given sex are as follows:

TABLE XXII—NORTH AMERICAN INDIANS

Males

Tribe	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Sioux	Sullivan	536	172.9	51.4	286.3
" (mixed)	Sullivan	77	173.5	51.6	286.7
Shoshonean	Boas	105	166.1	52.2	286.9
Apache	Hrdlička	60	169.7	53.2	294.5
Shuswap	B A A S	38	165.2	52.4	287.4
Chilcotin	B A A S	33	165.1	52.5	288.0
Pima	Hrdlička	35	171.8	52.9	294.1
Eskimo	Moore	61	162.7	54.3	296.4
Kwakiutl	B A A S	36	164.4	54.9	300.7
		Females			
Sioux	Sullivan	156	160.0	51.4	279.0
Pima	Hrdlička	30	157.4	52.3	282.3
Okanagua	B A A S	35	156.5	52.4	282.5

Tribe	Investigator	Males Number of individuals	Mean stature	Relative sitting	Index of rel. sitting ht.
Shuswap	B A A S	28	155.0	52.8	283.6
Apache	Hrdlička	29	157.2	52.8	285.0
Shoshonean	Boas	21	152.8	52.8	282.2
Kwakiutl	B A A S	33	153.7	55.4	296.7
Eskimo	Moore	46	151.7	55.7	297.1

Of the numerous Northwestern tribes for which data are cited by Bean from the B. A. A. S. reports all show for males an index lying between 283.6 and 289.7 inclusive, for females an index between 281.5 and 286.8 except the Timeh, (male stat. 163.7 cm., index 297.6), Bilqula (male, stat. 166 cm., index 295.7), Nass River (male stat. 167 cm., index 295.7, female, stat. 154.3 cm., index 293.4) and the Kwakiutl tribes (male, stat. 164.4 cm., index 300.7; female, stat. 153.7 cm., index, 296.7). The latter indices are similar to those based on the data cited from Moore for the Eskimos. The data cited from Boas for Eskimos give lower indices (12 M, stat. 167.5 cm., index 294.9; 11 M, stat. 167.9 cm., index 290.2; 6 F, stat. 155.6 cm., index 281.8; 6 F, stat. 151.5, index 286.3). The data cited from Duckworth given uncharacteristically low indices for Eskimos (10 M, stat. 157.7 cm., index 277.7; 17 F, Stat. 149.7 cm., index 282.5).

The following table based on data cited by Bean shows that the average index for male Indians of Mexico and Central America is lower than for the northern tribes.

Table XXIII—Mexican and Central American Indians

Tribe	Investigator	Males Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Mexican and Central American	Starr	2,276	157.5	52.4	283.0
Tarascan	Starr	100	160.0	52.0	282.3
Zapotee	Starr	99	160.5	51.6	280.4
Pima	ten Kate	77	169.6	50.7	281.2
		Females			
Central America	Starr	25	139.9	54.5	282.9
Mexico & Central America	Starr	573	145.3	53.1	279.2
Pima	ten Kate	51	156.3	51.5	278.0

The data cited by Bean for the Arawaks and Machiganga of South America give indices similar to those of negroes in their native haunts as may be seen in the following table:

Table XXIV—South American Indians

Tribe	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
		Males			
Arawaks	ten Kate	16	155.0	51.2	275.0
Machiganga	Ferris	18	155.9	50.1	269.6
Arawaks	Farrabee	9	159.4	51.4	278.7
Arawaks	Farrabee		161.5	50.7	276.1
		Females			
Machiganga	Ferris	15	143.9	51.8	271.4
Arawaks	Farrabee	6	147.9	51.7	273.4

On the other hand the indices of the Quichua and the Fuegians approach those of the northern American Indians and those of the Aymara are similar to those of the Eskimos and some of the northwestern tribes as may be seen in the following table:

Table XXV—South American Indians

Tribe	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
		Males			
Quichua	Ferris	228	158.4	52.7	285.1
Fuegians	Hyades and Deniker	25	157.7	52.7	284.7
Aymara	Forbes	17	156.4	54.6	294.2
Aymara	Chervin	104	159.7	54.8	297.3
		Females			
Quichua	Ferris	68	145.4	55.6	292.4
Quichua	Chervin	8	154.1	53.8	288.4
Aymara	Chervin	7	147.8	54.6	288.7
Fuegians	Hyades and Deniker	53	147.3	53.1	280.4

MONGOLOIDS

The index of relative sitting height of the 22 Chinese in our army at demobilization was 288.9, of 32 Japanese, 285.3. For 1,267 "Asiatics" Bean gives an average stature of 165 cm. and a relative sitting height of 53.5. These figures give an index of relative sitting height of 293.4.

The following table shows the indices based on data cited by Bean for the Chinese and Annamese.

Table XXVI—Chinese and Annamese

Group	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Setchuoen	Legendre	100	161.1	53.4	290.6
Island	Hagen	49	161.4	53.2	289.7
Annam	Roux	69	162.3	53.8	293.5
Annam	Vaillant	117	164.6	53.1	291.0
North Chinese Soldiers	Koganei	942	167.5	53.6	295.5
South Chinese	Koganei	90	168.5	53.2	293.8
Chinese women	Pyle	25	151.5	53.0	282.5

For Lolos and Tibetians we find the following figures:

TABLE XXVII

Group	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Lolos	Delisle	15	162.5	51.6	281.4
Tibetians, Males	"	30	164.3	53.0	290.3
Tibetians, Females	"	18	152.6	52.4	280.0
Lolos	Legendre	29	167.5	52.7	290.5
Lolos	"	13	168.4	52.6	290.5

The data from Koganei give higher indices of relative sitting height than those of other investigators and need confirmation before being taken as proof that the Chinese have so large a relative sitting height as that given. There is evidence that Koganei did not consider sitting height so important as other measurements made on Chinese prisoners of war.

For the 32 Japanese soldiers at demobilization the index of relative sitting height was 285.3. I have been able to find no statistics on the average sitting height of the native Japanese. Bälz, 1885, in his anthropometric studies of the Japanese gives the average trochanter height for several social groups, but from the data thus given, as quoted by Koganei 1903, no trustworthy deductions as to sitting height can be made. They appear to indicate an index of relative sitting height similar to that found by Koganei for the North Chinese.

Of the racial groups which have been supposed to have contributed to the Japanese race we have in addition to the data on the Chinese given above data on the sitting height of the Aino and of various Mongoloid and Malaysian groups.

According to Koganei, as cited by Bean, the average stature of 90 male Ainos was 156.8 cm., the relative sitting height 52.9. These figures give an index of relative siting height of 285.3. For three groups of Aino women Bean cites the data on which the following table is based:

TABLE XXVIII—AINO WOMEN

Number of individuals	Mean Stature cm.	Relative sitting ht.	Index of rel. sitting ht.
3	142.7	54.2	283.2
55	146.8	53.4	281.7
13	149.5	54.6	289.8

The following table based on data cited by Bean illustrates the indices of relative sitting height characteristic of Malayan groups.

TABLE XXIX—MALAYANS

Group	Investigator	Number of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
		Males			
Bughis	Knocker	6	154.4	52.6	282.2
Bughis	ten Kate	9	156.8	51.1	275.6
Sikanais	ten Kate	10	159.4	50.8	275.4
Rotinais	ten Kate	27	160.5	50.2	272.8
Soumbanais	ten Kate	14	160.9	50.5	273.7
Macassars	ten Kate	12	161.5	50.8	276.6
Borneo	Hose &McDougal	13	153.9	51.8	277.6
"	"	94	155.8	51.6	277.6
"	"	7	156.0	50.9	273.9
"	"	42	157.3	51.5	278.0
"	"	49	158.9	51.6	279.5
Dayahs	Knocker	33	157.0	52.5	283.8
Malay Penninsula	Annandale & Robinson	37	158.4	52.0	281.3
Java	Garrett	17	157.1	52.5	283.3
Sondanese	Garrett	37	159.1	52.0	281.8
Javanese	Kohlbrugge	105	160.4	51.5	279.8
Battak	Hagen	40	160.2	52.6	285.6
Malays	Hagen	27	160.0	51.6	280.1
Philippines Malay	Bean	183	159.5	52.6	285.3
Mestizo Malay		377	163.3	52.5	286.8
Batavians	Garrett	40	163.4	52.3	285.9
		Females			
Rotinais	ten Kate	27	148.3	50.4	266.7
Soumbanais	ten Kate	10	152.6	51.1	273.0
Borneo	Hose & McDougal	3	145.0	51.4	270.0
"	"	6	149.3	51.9	275.3
Dayaks	"	25	145.4	51.8	272.3
Malay Philippines	Bean	63	147.8	53.1	280.4

Admixture of negrito blood may account for the low index of relative sitting height of the native of the Timorian archipelago reported by ten Kate. He states that the Rotinais, especially, give indications of this. The Battak, the Batavians and the Malays of the Philippine Islands show a higher index than the continental Malayans, Javanese and Sondanese.

The Polynesians, much greater in stature, appear to have an index of relative sitting height similar to that of the Philippine Malays. The following table is based on data from ten Kate, 1916.

TABLE XXX—POLYNESIANS

Group	No. of individuals	Mean stature	Relative sitting ht.	Index of rel. sitting ht.
Tubuai	4 M.	171.2	51.5	286.0
	1 F.	170.6	50.5	280.0
Tuamotu	5 M.	172.4	51.4	286.0
Rapanui	4 M.	172.4	50.8	282.6
Tahitans	14 M.	172.8	51.0	284.1
	11 F.	159.1	51.3	278.0
Cook	4 M.	175.6	50.7	283.9
Marquesas	1 F.	160.4	53.9	292.9
Tonga	1 F.	164.8	52.0	285.1

Data cited by Bean for the following Mongolian and related groups of North Asia and Europe have been used in preparing the following table:

TABLE XXXI—NORTHERN MONGOLOIDS

Group	Investigator	Number of individuals	Mean Stature	Relative sitting ht.	Index of rel. sitting ht.
		Males			
Ostyaks	Rudenko	127	156.5	53.3	287.2
Voguls	"	75	156.7	52.9	285.2
Samoyeds	"	53	156.8	54.1	291.7
Yakuts	Mainow	207	162.4	53.1	289.7
Buryats	Schendrekowski	181	163.1	53.7	293.4
Kalmucks	Karolew	92	163.1	53.5	292.3
Tungus	Mainow	98	163.1	53.0	289.6
Maschtscher-Jaken	Weissenberg	15	163.6	53.2	291.0
Tartars	Pittard	2,341	163.6	52.6	287.7
Tartars	Benzengue	30	164.2	51.6	282.6
Esthonians	Gruber	100	164.3	53.7	294.0
Siberians (Tarantschen)	Paissel	307	164.6	53.5	293.2
Bashkiri	Weissenberg	68	165.7	53.2	292.2
Livonians	Waldhauer	100	173.5	51.4	286.7
Tartars	Pittard	15	178.5	51.6	290.5
		Females			
Tungus	Mainow	10	150.0	54.2	288.0
Yakuts	"	52	150.0	54.2	288.0
Yakuts	"	62	153.4	52.4	280.5

The indices for the groups in general are relatively high, though not so high as for several of the tribes of American Indians of the northwest. It is interesting to note that the Yakuts exposed to extreme cold in the winter have not an exceptionally high index of relative sitting height.

The indices of relative sitting height calculated in the tables given above from data from various sources show the value of this index in comparing the relative stem length of different ethnic groups. In making use of these data, however, it must be kept in mind that the methods

of measuring sitting height used by different investigators may vary. It is important that uniform methods be followed by anthropometrists in measuring sitting height. The most frequent source of error comes from measuring sitting height when the weight of the trunk is resting partly on the thighs. This may add 2 per cent or more to the relative sitting height. The thighs should be sufficiently flexed to throw the weight on the ischial tuberosities. To insure this Walker, 1916, Dreyer, 1920, Gray, 1922, and others have advocated measuring sitting height with the subject seated with flexed knees on a level surface. Gray would distinguish sitting height thus measured by calling it stem-length in contrast to sitting height measured in an ordinary seated posture. Sitting height from an anthropometric standpoint should, however, be the height of the body when the weight of the trunk is borne on the ischial tuberosities and therefore be the same as stem-length.

Stem-length is difficult to measure in the supine position. In measuring infants old enough to sit up and stand up I have found that the stem-length measured in the supine position is relatively greater compared with sitting height than is the supine body length compared with stature. The relative sitting height thus becomes increased when estimated from supine measurements.

Pfitzner, 1901–1902, in his interesting anthropometric studies on cadavers, measured "sitting-height" by taking the distance from the crotch to the vertex. The "sitting-height" thus measured on cadavers had an average relation to body length similar to what would be expected for sitting-height to stature in the living. *For 508 male cadavers, 20-50* years of age, from Strassburg and its vicinity, the average length was 167.5 cm., the relative sitting height was 52.6. This gives an index of 290. For 378 female cadavers, same age, the average length was 157.6 cm., the relative sitting-height 53.2. This gives an index of 287. The sitting-height measured in this way does not, however, vary relatively inversely as the cube root of the stature. It tends to be more constant so that the shorter individuals have a smaller, the taller individuals a larger average index of relative sitting height than that of the group as a whole. This is also true of stem-length measured by subtracting height to crotch from stature in the living. The following table based on data from Bertillon, 1889 (males 21–44 years) and from Pfitzner (males 20–100 yrs.) illustrates this.

TABLE XXXII

Index of relative sitting height for a given stature group compared with similar indices of relative stem-length when stem-length is taken as the difference between height-to-crotch and stature.

Data from Bertillon						*Data from Pfitzner*		
Mean stature	No. of indiv.	Relative sitting ht.	Index	Rel. stem-length	Index	Stature cm.	Rel. stem-length	Index
1.459	21	55.38	291.5	52.6	276.9	141–145	53.2	278.
1.513	128	54.87	292.2	52.5	279.6	146–150	53.5	283.0
1.559	522	54.28	292.1	52.1	280.4	151–155	53.0	283.5
1.607	1045	53.78	292.4	51.6	280.5	156–160	52.7	284.9
1.655	1177	53.19	292.0	51.5	282.7	161–165	52.6	287.3
1.703	800	52.85	292.7	51.0	282.7	166–170	52.4	289.1
1.751	313	52.25	292.3	50.6	283.0	171–175	52.0	289.7
1.797	65	51.88	292.8	50.8	286.8	176–180	52.1	293.1
1.843		51.28	291.7	51.6	293.3	181–185	51.6	293.0

GROUP INDICES

The index of relative sitting height used in this paper is essentially a group index. For a group of individuals similar in race, sex, and physiological age but varying in stature it indicates the way in which a given measurement, sitting height, varies with change in stature. It is an index not of build, but of variation in build relative to stature. For a given group the value of the index is determined by its constancy. The tallest individuals of the group should have the same index as the shortest. On the other hand relative sitting height is an index of build. Within a given group the taller individuals show a smaller relative sitting height than the shorter. The value of the index lies in its variability. It is important to keep in mind the difference between a group index designed to reveal constant relations within a group and an index of build designed to reveal individual differences.

The confusion which sometimes occurs in the use of the two types of indices comes from the fact that the relative measurement, index of build, is a factor in the determination of the group index. Another factor is the standard used as a basis of relative measurement, in this case, stature. At a given stature the sitting height, Si, relative sitting height $\frac{100 \text{ Si}}{\text{H}}$ and index of relative sitting heigh $\frac{100 \text{ Si H}^{1/3}}{\text{H}}$ all vary in the same proportions so that it makes no difference which is used in comparing one individual or set of individuals with another. Thus at stature 170 cm. a sitting height of 85 cm., a relative sitting height of 50.0, and an index of relative sitting height of 277, are each about 5 per cent

less than a sitting height of 89.25 cm., relative sitting height of 52.5, and an index of relative sitting height, 290.8. It makes no difference which is used for the purpose of making comparisons. The situation is, however, different when individuals of different statures within a group are compared. Thus, if we compare an individual 170 cm. tall, sitting height 89.25 cm., relative sitting height 52.5, index of relative sitting height 290.8 with one 160 cm. tall, sitting height 85.7, relative sitting height 53.56, index of relative sitting height 290.8, we find a difference in sitting height of about 4 per cent, in relative sitting height of about 2 per cent, and no difference in the index of relative sitting height. The differences in the proportions of the body in the two individuals are indicated by the relative sitting height, or index of build.

The value of the index of relative sitting height in comparing two groups of individuals varying in stature lies in the fact that it offers a short cut to the comparison of the relative sitting height of individuals of a series of given statures in one group with those of the same series of statures in the other group. In so far as the generalization that relative sitting height varies inversely as the cube root of the stature holds good for each group the results of comparing the index of relative sitting height of one group with that of the other group are the same as the direct comparison of the average sitting heights for given statures in each group, or of the relative sitting heights for each stature in each group. The available data indicate that the generalization on which the index is based is sufficiently in accord with facts to make the use of the index of value. From the group index the probable relative sitting height, for any individual within the group may be calculated if his stature is known or his stature, if his sitting height is known.

The index of relative sitting height deals with the average relative sitting height at any given stature in the group. At any given stature, however, there are individuals with relatively long lower extremities for that stature, those with lower extremities of average length and those with short lower extremities. These three groups have been termed by Manouvrier (1902) makroskèles, mesatoskèles and brachyskèles. The brachyskèles are usually but not always of more stocky, the makroskèles usually, but not always of more slender build than the average. No sharp lines of demarcation can be drawn between the central group and the other two groups. The variation in sitting height at a given stature is best indicated by the coefficient of variation. Data on this are at present scanty. We have seen above that for students entering college the average coefficient of variation in sitting height for a given stature

was about 3.10 per cent for males, 2.30 per cent for females. On this basis we should expect a probable deviation of the individual from the sitting height calculated from the index of relative sitting height of about 2 per cent for a man, 1½ per cent for a woman. As we shall show below, for a given stature group the average weight relative to the cube of the sitting height varies inversely as the sitting height so that the weight varies approximately as the square of the sitting height. A 2 per cent variation in sitting height would therefore mean a 4 per cent variation in weight from the mean to cover weight variation due to variation in sitting height at a given stature. The probable variation in weight for college students is 6 to 7 per cent a variation greater than that estimated from the probable variation in sitting height at a given stature.

The group "constant" or index of relative sitting height is closely related to two other interesting group "constants." One of these may be called the index of relative weight. It is the index that Davenport, 1920, recently termed a "height-weight index of build" and is based upon the fact that in a group of individuals of like race, physiological age and sex, as in the U. S. troop at demobilization, body weight, *W*., varies approximately as the square of the stature, H^2, so that the weight divided by the square of the stature approaches a constant, $\frac{W}{H^2} = K$. This index is a group index rather than an index of build. Just as the term an index of build is more properly applied to relative sitting height than to the index of relative sitting height as defined above, so it is more properly applied to weight relative to the cube than to weight relative to the square of the stature. Assuming a constant density for the human body weight may be taken to express volume. As a measure of volume weight should be considered relative to the cube of the stature in the same way that a linear measure is considered relative to the stature. Relative weight $\frac{100\ W}{H^3}$ thus becomes an index of build in the same sense that relative sitting height or relative chest girth are indices of build. The group index $\frac{100\ W}{H^2}$ depends upon the fact that within certain groups relative weight, $\frac{100\ W}{H^3}$, varies inversely as the stature; $\frac{100\ W}{H^3} \times \frac{H}{1} = \frac{100\ W}{H^2}$ = a constant. I have found that for students enter-

ing college, as Davenport found for U. S. troops, that the relative weight varies inversely as the stature, but that the shorter individuals are heavier, the taller lighter than if the formula $\frac{100\ W}{H^2}$ = a constant held perfectly. Table XXXIII shows the $\frac{100\ W}{H^2}$ ratio for college

TABLE XXXIII

Weight relative to square of stature and to cube of sitting height in college girls, median age 19, arranged in stature groups. The range for each stature group is 3mm above and below the stature given. The weight and sitting height represent averages for each stature group:

Stature Cm.	No.	Weight grams	$\frac{100\ W}{H^2}$	Sitting Height	$\frac{100\ W}{Si^3}$
151.1	11	48262	212	81.8	8.83
152.3	24	49442	213	81.8	9.02
153.7	22	50757	215	82.6	9.02
154.9	31	51800	216	83.6	8.89
156.2	40	51506	213	83.1	9.05
157.5	56	53887	217	83.6	9.22
158.8	45	60340	216	84.3	9.05
160.0	64	53569	210	85.1	8.69
161.3	48	56155	216	85.9	8.89
162.6	60	55928	212	85.9	8.83
163.8	47	56835	212	86.4	8.83
165.1	47	56200	206	86.6	8.64
166.4	26	56790	205	86.6	8.61
167.6	42	57107	203	88.1	8.33
168.9	13	58422	205	88.4	8.48
170.2	20	58422	202	88.6	8.39
171.5	9	62914	214	90.2	8.58

women at different statures. The ratio for college men is similar to that of the women. It is slightly smaller than that found by Davenport for the troops at demobilization. This difference is probably due to age. The Medico-Actuarial statistics show an increase in the $\frac{100\ W}{H^2}$ ratio for successive age groups, but for each age-group the ratio is fairly constant except at the extremes of stature.

Variation in relative weight inversely as stature appears to hold true only in case of groups of individuals of similar physiological age. Groups of young adults such as college students or the troops in the recent war are of this character. So also are groups of adults at successive age periods. During childhood, on the other hand, tall and short children of a given age are likely to be in different stages of physiological de-

velopment, the tall are apt to be accelerated in growth, more mature, as compared with the short, and to have a $\frac{100\ W}{H^2}$ index characteristic of this greater maturity. This is illustrated in the stature groups in table XXXIV, as compared with the age groups.

In young infants, on the other hand, in whom the affects of acceleration and retardation of growth are less marked, the data compiled by Woodbury show that at successive age periods the relative weight, $\frac{100\ W}{H^3}$, varies very nearly inversely as the stature.

Weight, (W), as an expression of volume is equivalent to rectangular width (T) times rectangular depth (D) times the stature (H). Relative weight thus becomes an index of rectangular cross section relative to square of stature. $\frac{W}{H^3} = \frac{T \times D \times H}{H^3} = \frac{T \times D.}{H^2}$ Rohrer, 1908, who introduced this index correctly termed it a formula for determining the *Körpefülle*. I have pointed out, 1919, that the square root of this index, with due regard to decimal points, makes a convenient measure with which to compare horizontal linear measurements, $\sqrt{\frac{W}{H^3}} = \frac{\sqrt{T \times D}}{H}$. Since relative weight varies approximately inversely as the stature we should expect the square root of relative weight to vary inversely as the square root of the stature. Since the square root of relative weight represents a rectangular relative horizontal diameter, $\frac{\sqrt{T \times D}}{H}$ and this varies approximately inversely as the square root of the stature we should expect a given horizontal linear measure such as chest girth (C) to vary as the square root of the stature in so far as the given measure follows the rectangular horizontal diameter in variability relative to stature $\frac{\sqrt{T \times D}}{H} \times \frac{H^{\frac{1}{2}}}{1} = \frac{\sqrt{T \times D}}{H^{\frac{1}{2}}}$ = a constant. Relative chest girth does, in fact, vary approximately inversely as the square root of the stature so that $\frac{C}{H^{\frac{1}{2}}}$ approximates a constant. As in the case of the $\frac{W}{H^2}$ constant the ratio is only approximately constant. The shorter individuals show a larger, the taller a smaller ratio than that called for by the formula. Thus at statures 150, 155, 160, 165, 170, 175, 180 and 185 centimeters Davenport's data on recruits show the following $\frac{C}{H^{\frac{1}{2}}}$ ratios: 6.85, 6.58,

6.52, 6.47, 6.44, 6.44, 6.41 and 6.39. For male students at Wisconsin I find the following ratios at corresponding statures, 6.33, 6.37, 6.37, 6.35, 6.39, 6.43, 6.33, and 6.35. These ratios are based on chest circumference at expiration.

The third group index depends upon the fact that within certain groups, the average weight W, for a given sitting height Si bears an approximately constant relation to the cube of the sitting height, $\frac{100\ \mathrm{W}}{\mathrm{Si}^3} =$ a constant. This relation has been made use of in an inverse form by v. Pirquet 1916, 1920, in constructing his pelidici* standards for weight of children, $\frac{\sqrt[3]{10 \text{ times body weight in grams}}}{\text{Sitting height in cm.}} = 100$. It has likewise been made use of by Walker, 1916, and by Dreyer, 1920. It has not, so far as I know, been utilized for comparative racial anthropometric studies. Walker has shown that in the form in which he used it, *stem-length equals approximately the cube root of the weight times a constant*, the calculated and observed data correspond well for children varying in age divided into weight groups irrespective of age, but not for weight groups of college undergraduates of an approximately uniform age.

I have found that the ratio $\frac{100\ \mathrm{W}}{\mathrm{Si}^3}$ = a constant holds approximately

TABLE XXXIV

Weight relative to sitting height cubed $\frac{100\ \mathrm{W}}{\mathrm{Si}^3}$ and to stature squared $\frac{100\ \mathrm{W}}{\mathrm{H}^2}$ in girls grouped according to age, stature, sitting height, and weight. Based on the data on Worcester schoolgirls of Boas and Wissler 1904. Weight includes indoor clothing without shoes. The age groups each include a range of one year, the stature and sitting height groups each a range of 127 mm., the weight groups a range of 1.81 K for the lighter groups, 2.27 K for the heavier groups.

Age groups							Stature groups					
Age yrs.	No.	Stat. cm.	Sitt. ht. cm.	Wt. grams	$\frac{100\ \mathrm{W}}{\mathrm{Si}^3}$	$\frac{100\ \mathrm{W}}{\mathrm{H}^2}$	Stat. cm.	No.	Sitt. ht. cm.	Wt. grams	$\frac{100\ \mathrm{W}}{\mathrm{Si}^3}$	$\frac{100\ \mathrm{W}}{\mathrm{H}^2}$
							106.7	10	58.2	17736	9.02	156
6.5	97	112.0	61.6	19867	8.50	158	111.8	18	61.6	19414	8.25	155
7.5	128	117.1	63.9	21727	8.33	159	116.8	27	63.5	20910	8.19	153
8.5	142	122.1	66.0	23541	8.19	157	121.9	30	65.5	23854	8.47	161
9.5	147	127.0	68.0	26308	8.36	163	127.0	38	67.8	25855	8.30	160
10.5	170	133.0	70.5	29075	8.30	164	132.1	48	70.1	29075	8.44	167
11.5	199	137.2	72.6	31752	8.30	169	137.2	33	71.9	31248	8.41	166
12.5	201	144.3	75.8	36741	8.44	177	144.8	50	76.7	36922	8.19	176

*(For a critical review of the pelidici see Bardeen, 1922).

Age groups						
Age yrs.	No.	Stat. cm.	Sitt. ht. cm.	Wt. grams	100 W / Si³	100 W. / H²
13.5	183	149.9	78.8	40687	8.44	181
14.5	146	153.9	81.5	45631	8.41	193
15.5	134	156.9	83.5	48172	8.28	200
16.5	100	157.2	84.0	49306	8.33	200
17.5	64	159.1	85.3	51982	8.36	205
Mean					8.36	

Stature groups					
Stat. cm.	No.	Sitt. ht. cm.	Wt. grams	100 W / Si³	100 W / H²
149.9	48	79.5	41821	8.50	186
154.4	60	82.8	47491	8.36	199
157.5	61	83.5	50485	8.66	203
160.0	52	84.8	50442	8.25	197
162.6	37	86.1	53478	8.39	202
167.6	7	89.2	57606	8.14	205
172.7	3	88.4	61961	8.96	208
				8.39	

Sitting ht. groups			
Sitt. ht. cm.	No.	Wt. grams	100 W / Si³
58.4	9	18597	9.27
61.0	12	19414	8.58
63.5	38	21001	8.19
66.0	38	24040	8.36
68.6	50	27170	8.41
71.1	45	28939	8.05
73.7	40	33566	8.41
76.2	29	36423	8.22
78.7	37	40733	8.33
81.3	48	46085	8.58
83.8	53	49714	8.44
85.1	45	52028	8.50
86.4	29	52617	8.17
87.6	29	55248	8.22
88.9	15	56880	8.08
Mean			8.36

Weight groups			
Wt. gram	No.	Sitt. ht. cm.	100 W / Si³
18148	31	60.7	8.08
19958	44	62.5	8.19
21772	54	62.7	8.39
23587	68	66.3	8.11
26308	76	68.6	8.17
29029	69	70.5	8.25
31751	72	72.6	8.25
36287	62	76.2	8.19
40823	33	80.5	7.81
45359	39	81.8	8.30
47627	44	82.8	8.39
49895	46	83.1	8.66
52163	42	84.8	8.55
56669	15	86.1	8.91
61235	20	86.4	9.49
			8.30

true for averages for weight groups, sitting height groups, stature groups, and age groups in school children. See table XXXIV. For college students the ratio is not at all applicable to weight groups. See table

Table XXXV

Weight relative to sitting height cubed and to sitting height squared in college girls, median age 19 years, arranged in sitting height groups and in weight groups. The range for each sitting height group is 64 mm. above and below the sitting height given. The range for each weight group is 1.14 K above and below the weight given.

Sitting ht. groups				
Sitt. ht. cm.	No.	Wt. grams	100 W / Si³	100 W / Si²
78.7	13	45949	9.41	741
81.3	46	49079	9.13	742
83.8	111	52571	8.94	748
86.4	129	56382	8.75	754
88.9	57	56835	8.08	719
91.4	31	60691	7.94	726

Weight groups			
Wt. grams	No.	Sitt. ht. cm.	100 W / Si³
42094	29	82.3	7.55
46629	116	85.5	7.46
50256	192	85.4	8.20
55656	130	85.9	8.77
59965	120	86.3	9.33
64546	43	87.6	9.60
69127	33	87.6	10.29

XXXV. For sitting height groups the ratio $\frac{100\,W}{Si^3}$ varies approximately inversely as the sitting height so that $\frac{W}{Si^3} \times \frac{Si}{1} = \frac{W}{Si^2}$ approaches a constant. See Table XXXV. If the data are arranged in stature groups the average weight for each stature group divided by the cube of the average sitting height for the group approaches a constant, although there is a slight decrease in the ratio with increase in stature. See table XXXIII. If, however, the data for a given stature group are subdivided into sitting height groups and the average weight for each sitting height sub-group is divided by the cube of the sitting height this ratio varies inversely as the sitting height so that again $\frac{W}{Si^3} \times \frac{Si}{1} = \frac{W}{Si^2}$ approaches a constant.

TABLE XXXVI

College women, stature 160–160.5 cm., subdivided into sitting height groups. The range for each sitting height sub-group is 64 mm. For each sitting height sub-group there are given the average weight, the $\frac{100\,W}{Si^2}$ index and the coefficient of variation in weight. For the whole group the mean weight was 53.31 K, the mean sitting height was 85.2 cm. The coefficient of variation in weight was 13.8 percent, in sitting height 1.98 percent. The coefficient of correlation for weight-sitting height was 0.28.

Sitting height	No. of individuals	Mean weight grams	$\frac{100\,W}{Si^2}$	Coefficient of variation weight
81.3	2	49990	756	
82.5	5	54990	809	9.7
83.1	3	50260	731	11.5
83.8	20	49530	703	8.4
84.5	13	51750	795	10.4
85.1	19	55700	766	4.6
85.7	4	50800	621	11.3
86.4	14	54160	724	15.5
87.0	3	57470	759	1.6
87.6	9	54990	710	21.8
88.3	2	61920	795	
90.2	2	60550	745	
90.8	1	54660	664	
Average				10.5

See table XXXVI. This is also true for the period of childhood. If the data for a given stature group are arranged in sub-groups for sitting height the average weight for each of these sub-groups divided by the square of the sitting height approximates a constant. See table XXXVII.

Table XXXVII

Weight relative to the cube of the sitting height and to the square of the sitting height in girls 131.5–134.0 cm. in stature grouped according to sitting height. Based on data from Boas and Wissler 1904. Average age 10.7 yr. (σ 0.93 yr.); average stature 132.6 cm. (σ 0.6 cm.); average sitting height 70.4 cm. (σ 1.9 cm.); average weight 29.3 K (σ 2.77 K). Coefficients of correlation: age-stature 0.209; age-sitting height 0.337; age-weight—0.116; height-weight 0.025; sitting height-weight 0.395. The sitting height groups cover a range of 1 cm.

Sitting-height cm.	Number of individuals	Wt. grams	$\frac{100\ W}{Si^3}$	$\frac{100\ W}{Si^2}$
67.5	5	28123	9.15	618
68.4	12	30844	9.64	659
69.4	17	27715	8.28	575
70.3	20	29012	8.34	586
71.3	9	29212	8.05	574
72.5	6	30073	7.89	572
73.5	4	31434	8.00	589
74.4	2	30618	7.44	553
75.9	1	30391	6.95	528
76.2	1	29483	6.67	508

In both cases there is a wide individual variability and the shorter groups are heavier and the taller lighter than would be the case were $\frac{100\ W}{Si^3}$ to vary exactly inversely as *Si*. In the group of college girls, table XXXVI, the coefficient of variation in weight for stature 160 cm. was 13.8 per cent. The average coefficient of variation for the sub-groups was 10.5 per cent. For the school girls, table XXXVII, the coefficient of variation in weight for the group as a whole was 9.45 per cent. The average coefficient of variation for the sub-groups was 8.05 per cent. In both cases the variability in weight is somewhat reduced if weight is considered from the standpoint of sitting height as well as from that of stature. Baldwin, 1921 found an average positive coefficient of correlation of 0.177 for weight-sitting height in school-girls, 7-17 years of age, at given stature groups. The value of the coefficient varied irregularly at different age periods. The coefficient of correlation for weight-sittingheight which I find for the group given in table XXXVII is much higher than the average reported by Baldwin. I have found in general higher coefficients of correlation for weight-sittingheight in stature groups than those reported by Baldwin. For the 120 cm. stature group of the Boas and Wissler school girls I find, for instance a weight-sitting height coefficient of correlation of 0.48. For the college women of table XXXVI it was 0.28.

Since in the adult the weight when the individuals are arranged in

sitting height groups varies as the square rather than as the cube of the sitting height the tables of Dreyer in his "Assessment of Physical Fitness" are in part fallacious. The lower limbs should not be ignored in preparing proper tables of physical fitness.

The relations between the three group ratios $\frac{Si\ H^{\frac{1}{3}}}{H} = K_1$, $\frac{W}{H^2} = K_2$ and $\frac{W}{Si^3} = K_3$ may be shown as follows:

$$W = H^2K_2,\ W = Si^3K_3,\ H^2K_2 = Si^3K_3$$

$$Si^3 = H^2\frac{K_2}{K_3},\ Si = H^{\frac{2}{3}}\sqrt[3]{\frac{K_2}{K_3}} = H^{\frac{2}{3}}\ K_1$$

$$Si^3 = H^2K_1^3,\ \frac{Si^3}{H^2} = K_1^3,\ \frac{H\ Si^3}{H^3} = K_1^3,\ \frac{H^{\frac{1}{3}}Si}{H} = K_1,\ \frac{Si}{H} = \frac{K_1}{H^{\frac{1}{3}}}$$

Si = sitting height, H = stature, W = body weight, K_1, K_2, K_3 are constants.

Of the three group indices the first and second appear, as stated above, to be more applicable to adult groups than the third, the third appears to be more applicable to groups during childhood than the first and second.

SUMMARY

1. In adults of similar physiological age, race, and sex the relative sitting height varies inversely as the cube root of the stature, $\frac{Si\ H^{\frac{1}{3}}}{H} = K = \frac{Si}{H^{\frac{2}{3}}}$. *This is illustrated by* statistics of troops at demobilization, table I, statistics on college students, tables II, III, IV, and the data of Bertillon on the French, table XXXII. Relative chest girth varies inversely as the square root of the stature $\frac{C}{H} \times \frac{H^{\frac{1}{2}}}{1} = K = \frac{C}{H^{\frac{1}{2}}}$. See p. 380.

2. Incollege students the coefficient of variation in relative sitting height at a given stature has been found to average about 3.10 per cent for men, 2.30 per cent for women.

3. The $\frac{100\ Si\ H^{\frac{1}{3}}}{H}$ ratio appears to offer a good index for comparing sitting height in different racial, social and sexual groups of adults since it offers a means of comparing the relative sitting heights at corresponding statures in different groups. The value of the ratio based

on average stature sitting height is given for a large number of racial groups. The data of Bean, 1922, which recently appeared in this journal have been utilized for this purpose. A ratio of 290 or over represents a high index, one of 280 or under a low index. Those with "Nordic" blood, northern Mongoloids, Esquimaux, and Northwestern American Indians represent the main groups of those with high index. Of other such groups mention may be made of the Armenians among Caucasians and of the Aymara among the South American Indians. The negroes, negritoes, the primitive races of southern India, the Malayans of many of the islands southeast of Asia and the Indians of the northern part of South America have a low index. The Australians have a much lower index than any other group. The pigmies of Africa have a higher index than the true negroes. The "Hamitic" tribes of Africa, have, many of them, an index which is similar to that of the negroes.

4. An ethnic or group "constant" used as an index should be distinguished from an index which represents relative proportions. The ethnic or group index refers to the group as a whole and should be approximately constant for the group. It makes possible the comparison of groups composed of individuals of different average size in so far as bodily proportions vary with size in a similar manner in each group.

5. The group index, $\frac{100 \text{ Si } H^{1/3}}{H}$ = a constant, is mathematically related to two other group indices, $\frac{100 \text{ W}}{H^2}$ = a constant and $\frac{100 \text{ W}}{Si^3}$ = a constant.

6. The $\frac{100 \text{ W}}{H^2}$ ratio approaches a constant in groups of individuals of similar race, sex, age and physiological development, see table XXXIII, because within such groups average relative weight, $\frac{100 \text{ W}}{H^3}$, varies inversely as the stature $\frac{100 \text{ W}}{H^3} \times \frac{H}{1} = \frac{100 \text{ W}}{H^2}$ = a constant. It is of value chiefly in comparing groups of adults. It is applicable to infancy, but not to childhood because during childhood acceleration and retardation of growth make it impossible with our present knowledge to select groups of individuals of the same physiological age, but varying in stature. See table XXXIV.

7. Weight relative to sitting height, $\frac{100\ W}{Si^3}$, approximates a constant for school children for averages in age groups, stature groups, sitting height groups, and weight groups, table XXXIV. For sitting height groups at a given stature, however, weight relative to sitting height, $\frac{100\ W}{Si^3}$, varies inversely as the sitting height so that $\frac{100\ W}{Si^2}$ approaches a constant, table XXXVII. This is also true of young adults, table XXXVI. In young adults and in infants, however, unlike the condition in childhood, $\frac{100\ W}{Si^3}$, varies inversely as the sitting height when the data are arranged in sitting height groups irrespective of stature, table XXXV. When young adults are grouped in weight groups the $\frac{100\ W}{Si^3}$ ratio increases rapidly from the lighter to the heavier groups. The usefulness of the $\frac{100\ W}{Si^3}$ ratio appears to be chiefly in the comparative study of groups of children.

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FETAL GROWTH IN MAN[1]

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Our knowledge of human growth after birth is well advanced, but comparatively little study has been made of growth in utero, and what has been published does not deal with the subject in a comprehensive manner, being either based upon insufficient material or restricted to some special problem.

From a collection of over 5,000 human embryos and fetuses in the Carnegie Laboratory of Embryology the author selected for study 623 of the best of the normal and well-preserved specimens, both white and negro, ranging in age from the ninth week to term. Of the results of the anthropological investigations of this material the more important general conclusions will be mentioned first.

RACIAL DIFFERENCES

These exist as early in development as the human form can be recognized; many of them become more marked with advancing growth, but some are as pronounced in fetuses of three months as in the newborn or even in the adult stage. These differences are essentially the same as those which distinguish adult whites from adult negroes. No racial differences in any part of the body were found to diminish with advance in growth; they all seem to develop in diverging directions. In many instances the greatest divergence is reached early in fetal life and growth thereafter proceeds in parallel directions. It seems hardly necessary to point out that this speaks strongly in favor of a monophyletic origin for at least these two human races. However, the author cannot agree with the view, repeatedly expressed to him, that the presence of racial differences so early in development can be interpreted as an indication of great antiquity of the races of man. Ontogeny furnishes no proof in this

[1] This article is a summarized preliminary report of the author's extensive investigations on this subject. These will appear in detail in the near future in Contributions to Embryology, published by the Carnegie Institution of Washington.

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problem, since the recapitulation theory cannot be applied to time; i. e., the time of first appearance of racial characters in prenatal development does not necessarily depend on the phylogenetic age of races. The author found, for instance, that the very recent races of pug-nosed and long-snouted dogs have their respective peculiarities indicated long before birth.

SEXUAL DIFFERENCES

Clear and unquestionable secondary sexual differences could not be demonstrated in any of the body proportions; the general size, however, is slightly greater in the male than in the female during the last two months of prenatal life.

VARIABILITY

Individual differences in fetuses are very considerable; in other words, variability before birth is at least as pronounced as in adult life. This not only holds true for measurements but can be shown in even the smallest details. Individual characteristics in facial expression, for instance, can be readily recognized, after some experience, even in very young fetuses. The coefficients and relative ranges of variation for the proportions on the fetal body in specimens of approximately equal ages are in general about the same as for the corresponding proportions in adults; indeed, not infrequently they are even higher. As a rule, the variability is slightly greater in the first than in the second part of fetal development, and is certainly as fully pronounced in the smallest embryos as in fetuses. The variability in fetuses does not seem to be correlated with rapidity of growth, since the latter undergoes very marked changes. Here it may also be mentioned that the variability in the total length of the upper, as well as of the lower extremity, was found to be less than that of the single components of an extremity, which signifies that the parts of a limb show a tendency to compensate each other in their variations in length. For instance, in fetuses of equal ages the relative ranges of variation for the total length of the upper limb average 8.48; for the upper arm, 9.88; for the forearm, 9.20; and for the hand, 11.23.

ASYMMETRIES

Differences between the two halves of the body do not begin to develop in childhood, as is commonly supposed, but appear early in fetal life. They could be clearly demonstrated from the beginning of the fourth

month on, and, with an especially precise technique, some asymmetries could no doubt be found even earlier. In fetuses from the fourth month to term the humerus, for instance, was longer on the right side in 57.6 per cent, longer on the left in 18.2 per cent, and equal on the two sides in 24.2 per cent of the cases. The difference in length of the two humeri amounted on an average to nearly 1 per cent of the smaller measurement.

From these general results it seems most probable that racial and individual differences, as well as asymmetries, are very closely dependent upon heredity. They certainly make their appearance very early in development, long before environment or function could exert any noteworthy influence. Secondary sexual differences, only, develop comparatively late, and then under the stimulation of the sex glands.

One of the most interesting problems regarding *absolute* measurements exists in their relative increments, particularly in the changes in these during the course of growth. These relative increments for all measurements on fetuses are greatest during the third month, whereafter they decrease rapidly up to the ninth month in case of measurements on the trunk, up to the eighth month in case of measurements on the limbs, and up to the eighth, ninth, or tenth month in case of the various measurements on the head. From these stages of fetal life to birth the relative increments increase again quite noticeably, which indicates a certain fluctuation in the rate of growth. This is exemplified in the accompanying table, which gives the averages of the relative weekly increments, within each month, of the anterior height of the trunk and of the biacromial diameter. These figures decrease up to the

Month	3rd	4th	5th	6th	7th	8th	9th	10th
Ant. trunk ht.	29.2	18.0	9.5	8.2	5.7	5.0	1.6	5.4
Biacrom. diam.	24.3	19.3	11.1	6.2	4.8	3.5	2.4	6.2

ninth month and increase again in the tenth month. In addition they show that in the third month the rate of growth is greater in the height than in the width. In the fourth and fifth months this condition is reversed, only to change back again in the sixth, seventh, and eighth months, and to change a third time in the ninth and tenth months to a preponderance in rate of growth of the width diameter over the height diameter. Alternations such as that between growth rate of height and of width, or of extremity and of trunk, can be demonstrated in many

measurements on the fetal body. It is well known that these fluctuations, as well as alternations, in rate of growth occur during postnatal development, and it is of great interest to find them also during growth in utero.

The alternations in relative increments naturally lead to changes in *proportions*, and it is to such changes, particularly those occurring in fetal life, that special attention has been given by the author. Only the more general ones can be outlined in this paper; the trunk will be considered first, next the extremities, and lastly the head. Wherever the proportions differ in the two races this will be mentioned and an occasional comparison be made with conditions of growth in other primates. The author has examined a considerable number of these, representing various species, at different fetal stages as well as at older stages of development.

TRUNK

In general, the trunk becomes more and more slender as development advances, as evidenced by the fact that the circumference of the chest (at nipple height) amounts to 238 per cent of the trunk height (symphysion-suprasternale) in fetuses of 9 weeks, decreasing to 178 per cent in newborns and to 168, or slightly more, in adults. The width between the hips increases faster than the biacromial width. In white fetuses of 9 weeks the former constitutes only 58 per cent of the latter, but this percentage increases to 84 at birth and to 91 in adults. In negroes these figures are less than in whites at all stages of development; i. e., negroes have slightly narrower hips in relation to the shoulders. Analogous ontogenetic changes in this proportion between upper and lower breadth of the trunk take place also in other primates. The chest becomes relatively broader with advancing development; at 9 weeks its transverse and sagittal diameters are still practically alike, but very soon afterwards the former surpasses the latter. The umbilicus shifts to a relatively higher position on the trunk in the course of fetal as well as postnatal growth, a rule which seems to hold true also for all monkeys and apes. Man has the lowest placed nipples of any of the primates; this extreme position is not reached, however, until growth is completed, the nipples being situated higher in the fetus than in the adult. In relation to the ribs, the nipples overlie the second intercostal space in young fetuses, but have shifted down to the fourth intercostal space in adults. In fetuses of monkeys and apes the nipples occupy a relative position on the trunk similar to that in human

fetuses, but in contrast to man, they shift upward in the course of growth, so that these different specializations in man and monkey in regard to the position of the nipples are not attained until relatively late in life. In the human fetus the shoulders lie rather high above the suprasternal notch, so that the lateral ends of the clavicles stand much higher than their medial ends. In adult whites the clavicles, when in a position of rest, are horizontally posed, but in adults of primitive races they have descended less from their fetal position.

UPPER EXTREMITY

In relation to the height of the trunk, the total length of the upper extremity undergoes marked changes throughout the entire growth period; these consist of alternating increases and decreases. At nine weeks of intrauterine life the upper limb is still slightly shorter than the trunk; at ten weeks it has surpassed the latter, growing at a rapid rate up to the end of the fifth month, when its length is one and a half times the height of the trunk. For the whites measured by the author, this is the greatest relative length of the upper arm reached anywhere during growth. After the fifth month until birth a considerable decrease takes place in this relative measurement, but during postnatal life the upper extremity in general again surpasses the trunk height in rate of growth. The fact that the upper limb reaches a maximum relative length in the middle of fetal development may be regarded as lending support to the theory that at some time in the evolution of man his arms were longer than they are in recent human races.

The upper arm–forearm index increases during fetal life; in other words, the forearm grows faster than the upper arm. This stands in direct opposition to the claims made by Hamy, and more recently by Mendes Corrêa, that the relative length of the forearm decreases in the course of intrauterine growth. These authors had measured only 22 and 10 specimens respectively, and these series are too small to reveal the typical age changes. As in man, the upper arm–forearm index in apes and monkeys is smaller in the fetus than in the adult; but of all primates man has the relatively shortest forearm. Adult negroes have longer forearms in relation to their upper arms than adult whites. This racial distinction appears early in fetal life and can be demonstrated at all subsequent stages of growth. A typical example for the alternations in growth rate in different parts of the body is furnished by the proportion between the length of the hand and that of the forearm. At 9 weeks

of fetal life the former is nearly one-fifth longer than the latter; during the third and fourth months the forearm grows much more rapidly than the hand, so that the corresponding index drops in this short interval to less than 73; from the beginning of the fifth month to birth the hand again becomes relatively longer; i. e., the index rises steadily to about 95. Finally, in postnatal life the index drops a second time to a considerable extent, the hand length in adults forming only 75 per cent of the forearm length. With advancing growth the hand becomes more and more slender, but is always slightly broader in whites than in negroes. The thumb, when measured from the styloid process of the radius to the tip of the digit, becomes steadily shorter, in relation to the greatest hand length, from the third month to birth and is, at all stages of growth, somewhat longer in whites than in negroes. The same ontogenetic reduction of the relative length of the thumb was found in other primates also, but here the final shortening goes much farther than in man. The place of attachment of the free thumb to the hand shifts more and more proximally in the course of development; in a fetus of 9 weeks the thumb branches off immediately beneath the base of the index finger, while in adults this branching occurs relatively much closer to the wrist. In fetuses of 8 weeks the transverse axis of the thumb, as determined by its nail anlage, forms a very small angle with the transverse axis of the other fingers; soon afterwards, however, the thumb rotates to nearly the extent of a right angle, assuming the typical position of opposability which it occupies in adult man. In all monkeys and apes the fourth finger is longer than the second; this relation holds true also for most negroes, but in the whites these two fingers, in over half of all cases observed, were of equal length, and in more than 10 per cent of the cases the second finger even surpassed the fourth in length. These relations change but little throughout prenatal and postnatal development.

LOWER EXTREMITY

The proportion between the total length of the lower extremity (from the great trochanter to the sole of foot) and the height of the trunk changes very considerably during ontogeny. At 9 weeks of fetal life the length of the lower limb constitutes only 72 per cent of the trunk height; at the end of the third month the two measurements are alike; at the end of the fifth and during the sixth month the maximum in relative limb length of the entire fetal period is reached, being at one time 140 per cent of the trunk height. In the following months this

index decreases again down to 116 in newborn whites. During postnatal life there takes place a second increase, which brings the index to 175 in male adult whites. This tremendous development of the lower limb in man is entirely unparalleled in other primates. However, this human distinction does not come about until comparatively late in growth, since at birth the relative length of the lower extremity in most monkeys and apes is fully as great as, if not greater than in the human newborn.

The thigh-leg index, like the corresponding index on the upper limb, increases in general with advancing growth; in fetuses of 9 weeks this index in the white race amounts to only 65, at birth it is 79, and in adults 84. Negroes have slightly higher values for this index from the end of the third prenatal month to adult life. It can be stated, therefore, that on both the upper and lower extremities the more distal parts, radius and tibia, grow faster than the proximal parts, humerus and femur, and are relatively longer in the negro than in the white. The foot, like the hand, becomes relatively narrower in the course of growth and, likewise, is relatively less broad in the negro than in the white fetus. Very early in fetal life the soles of the feet stand parallel to the midsagittal plane and thus face inward; during ontogeny the feet rotate until the soles face downward and occupy a horizontal position. This initial supinatorial position of the feet is not caused by conditions of space or pressure within the uterus, as has been assumed by some writers, but is the result of an inherent law of fetal growth, causing many changes in at least the tarsal region, such as a slight rotation of the tuber calcanei and a shifting of the tarsus from the fibular to the tibial side. Typical for the negro, well marked even in small fetuses, is the prominence of the heel, which, as a rule, is due to a very thick layer of subcutaneous fat overlying the calcaneus.

The relation in length between the first three toes undergoes some important changes during development. In all monkeys and apes the middle toe surpasses all others in length, and it is interesting to note that man occasionally also conforms to this rule, although only for a very short transitory stage in his ontogeny, since in a fair percentage of fetuses from the end of the second and the beginning of the third month the middle toe is the longest. Very soon afterward the second toe becomes the longest in the large majority of cases; not until the fourth month does the great toe project farther than any of the other toes, and then only in a small minority of cases. The frequency of instances in which the great toe is shorter than toe II decreases in both races with advance in fetal development, but such

cases always remain much more common in the negro than in the white. The human foot is very different from the feet of other primates in adult life; however, early in intrauterine development this distinction is not nearly as pronounced. At this stage the hallux is markedly abduced and all metatarsals are divergent instead of parallel, as in the adult. Furthermore, in all primates, including man, the great toe at the beginning of fetal life is considerably shorter than the second toe, but in the course of growth the former approaches or even surpasses the latter in man, whereas in the other primates it becomes progressively shorter. The phalanges of the lateral toes are shorter than the corresponding metatarsals in young fetuses, both human and ape; but during development they become relatively still shorter in man and just the opposite, relatively much longer, in other primates. In some human fetuses of 8 weeks it was observed that the hallux was slightly rotated toward the other toes, and this in the sense of opposability; very soon afterwards, however, the transverse axis of the great toe runs in the same direction as the transverse axis of the lateral toes.

RELATION BETWEEN TOTAL UPPER AND TOTAL LOWER EXTREMITY

This interrelation is best demonstrated in the intermembral index, which expresses the length of the former in percentage of the length of the latter. From 133 in fetuses of 9 weeks, this index in whites drops to 104 at the end of the sixth month; thereafter to birth the averages remain about the same. During postnatal life a second drop takes place in whites, reducing the index to 82.5 in the adult. From this it can be stated that the lower extremity grows faster than the upper during the first part of fetal development, and again during life after birth, and not until early infancy does the length of the lower limb surpass that of the upper. Negroes at all stages of growth have higher indices than whites; i. e., the upper extremity of the negro is slightly more developed in relation to the lower extremity, and this constantly from early fetal to adult life. The variability of the intermembral index is very small; in fact, there exists a surprisingly close correlation between the length of the upper and the length of the lower limb throughout growth, so that hardly any other two measurements on the body show such a constant proportion. Among all adult primates man has the longest lower limb, not only in relation to the trunk, as shown above, but also in relation to the upper limb. Only in man and some of the lower primates, the prosimiae, does

the intermembral index sink below 100 when growth is completed; and even in the prosimiae the index never decreases to the extent shown in the human adult. This distinction between man and apes and monkeys, however, does not exist in earlier stages of development; in human fetuses the proportional lengths of the limbs are well within the range of variation of this proportion in fetuses or adults of other primates. In all the monkeys, in gorilla, and in man the intermembral index is smaller in adults than in fetuses, a difference most pronounced in man. Only in chimpanzee, orang, and gibbon is a definite age change in this regard missing, due, most likely, to the specialized over-development of the arms in these apes.

Alongside of many striking resemblances in conditions of growth in the upper and lower extremities, a certain well-defined difference was found; i. e., the lower limb for a long period is a step behind the upper limb in development. This retardation of the lower, or acceleration of the upper limb, can be best recognized by means of the time of first appearance of (1) ossification centers in certain skeletal elements of the extremities, (2) cutaneous ridges on palm and sole, and (3) lanugo on arm and leg. All these features develop slightly later in the lower than in the upper extremity.

HEAD

It remains to consider briefly growth changes in the head. By measuring the greatest length, greatest width, and the height of the head, and dividing the total of these measurements by 3, the average head diameter is obtained. This diameter is expressed in percentage of the trunk height, thus giving a sensitive index for the relative size of the head. This index averages 95 in fetuses of 9 weeks; it decreases throughout growth, reaching 57 at birth and 31 in adults. In fetuses this relative head size was found to be slightly less in negroes than in whites, but in adults slightly greater. As in man, the index in all other primates decreases with advance in growth and the size of the index in monkeys and apes differs in general but little from that in man at corresponding stages of growth. For example, at birth man, with an index of 57, stands lower than orang and gibbon, with indices of 61 each, and is not far from chimpanzee, with an index of 50. At adult life man's index of 31 is equalled by such forms as the macaque and surpassed by Cebus, with its index of 39. Of the various head diameters the width is considerably more variable than the length or height. The cephalic index decreases during fetal life; in the third month it amounts

on an average to 87 and may be as high as 98. The index which expresses the face height in percentage of the head height averages 48 in white fetuses of 9 weeks and increases to 59 in white newborns and to 85 in white adults. This indicates that the face grows in height at a more rapid rate than the cranial part of the head. In negroes this index is at all stages of development considerably larger than in whites. Likewise, a proportionally greater height of the negro face in fetuses, as well as in adults, is obtained when the upper face height (naso-buccal diameter) is brought into relation to the circumference of the head. This index increases during growth in most primates, just as in man. The face itself changes its general shape but little during fetal development, since the proportion between height and width remains about stationary from the third month to birth; only in postnatal growth does facial height increase more rapidly than facial width.

During development the eyes of man and of other primates move constantly closer together. This is best demonstrated when the interocular width is expressed in percentage of the bizygomatic width. This percentage relation averages 51.8 in human fetuses of 9 weeks but only 25 in white newborns and 23 in adult whites. The most rapid decrease occurs during the third and fourth fetal months. In orang-utan this relative interocular width amounted to 29.3 in a specimen from the middle of fetal development, to 19.1 in a newborn, and to 12.2 in a juvenile. In some primates, such as orang, baboon and Cebus, the relative narrowing of the distance between the eyes goes much farther than in man.

In relation to the upper facial height, the height of the nose decreases in general during prenatal growth, but increases again in postnatal life. In negroes this relative nasal height is constantly smaller than in whites. This is an indication, also, that the upper lip is lower in the latter than in the former. The nasal breadth in percentage of the bizygomatic breadth decreases very markedly during fetal growth; at 9 weeks it amounts to 36, while in white newborns it is only 24.7. In all negro fetuses, as well as in adults, the relative nasal breadth is very much greater than in whites of corresponding ages. From the foregoing it can be anticipated that the nasal index, also, must show a marked racial difference, with the larger values in the negroes. This index decreases from 145.1 in white fetuses of 9 weeks to 100.6 in newborns and to 62.1 in adults. The negro nose is not only relatively shorter and much broader than the white nose, but also considerably blunter and less prominent. All these differences become apparent as early as the third month of fetal

life. Up to the end of the fourth month the nostrils are closed by epidermal plugs and are circular in form; after that time they become elongated, with their longitudinal axes in whites converging forward or, later on, even running parallel, while in negroes they usually occupy a transverse position.

In relation to the size of the head, the ear size increases with advance in fetal growth in all primates. The index used to express this relative ear size rises from an average of 1.3 in human (white) fetuses of 9 weeks to one of 5.9 in newborns, but decreases again thereafter to an average of 4.7 in adults. Man and orang-utan possess by far the relatively smallest ears of all the primates, and it is only in these two that the relative ear size was found to diminish again during postnatal growth. This can most likely be interpreted as an indication that in the evolution of man, as well as of orang, the ear has become smaller.

Many more growth changes and racial differences in fetuses could be enumerated, even from a study of the outer form alone. These examples, however, suffice to show that with anthropological investigations on ample fetal material, especially of different races, one enters an almost entirely untrod field, from which important additions to our knowledge of human growth may be expected. It is also highly probable that systematic studies in this field, in connection with those on the ontogeny of primates other than man, will eventually shed new light on man's evolution.

ON THE SUPRACONDYLOID VARIATION IN THE NEGRO

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My attention was directed to the question of the frequency of variation among negroes by observing the apparently slight tendency to the exhibition of the supracondyloid process.

An examination of a mixed group of dispensary patients, blacks and whites, numbering 1000 in all, revealed the presence of the supracondyloid process in seven individuals.[1] There were 515 adult whites, 6 of whom had the process as determined, first by palpation of the arms, second by use of the X-ray. The adult negroes numbered 248 and but one presented the variation. At the present moment 1000 adult negroes have been examined for evidence of the supracondyloid variation and as yet but the one case has been noted.

The unit chosen for study and comparison both among the whites and blacks has the following characteristics: stock, whites and blacks; sex, males and females; age, 21 years or more; residence at time of examination, State of Missouri; social status, patients of a free dispensary or hospital; mental condition, sound. The negroes were all native Americans as were the great majority, but not all of the whites. All patients in attendance at the dispensary or admitted to the hospitals' wards during the period of examination were included in the groups. A few exceptions were made of patients who, because of extreme fleshiness, disease or injury at the site of the variation, were unfavorable for the method or the purposes of the study; these were passed over.

The method of examination consisting in palpation of the lower one-fourth of the shaft of the humerus has been described in detail in previous publications.[2] The name "supracondyloid process" is here used in accordance with the definition of Hrdlička.[3] In this connection it

[1]Terry, R. J. A study of the supracondyloid process in the living. Am. Jour. Phys. Anthrop. Vol. IV, pp. 129–139. 1921.
[2]Terry, *ibid.* Cady, Lee D. The incidence of the supracondyloid process in the insane. Am. Journ. Phys. Anthrop. Vol. V, pp. 35–50. 1922.
[3]Hrdlička, Ales. Anthropometry. P. 126. The Wistar Institute of Anatomy and Biology. Phila. 1920.

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may be well to draw attention to the fact that this spine of 0.3 cm. or more in height is but one form taken by the supracondyloid variation. It was chosen for the evidence of the variation in the living, simply because it alone of all the five forms which have been recognized can be discovered and demonstrated with certainty by palpation.

Comparing the two similarly constituted groups, the one representative of the white race of a certain social status, the other of American negroes it appears that, by the same method of examination and by seeking the same criterion of evidence, viz., the process form of the supracondyloid variation, that this process was presented in six individuals of the white group (515 adults) and but one of the black group (1000 adults). Before reaching any conclusion with reference to these frequencies two comments must be made. First, as to the incidence of the process found by palpation in the white group, 1.16%; this is considerably lower than Hrdlička's result by direct observation of 1309 arm bones, half rights and half lefts, from dissecting room material. It is probable that a small process occurring in a muscular arm was overlooked in our examination. The point is that the frequency found in our group of whites is probably somewhat lower than the actual state. Second, as to the question of race mixture in the blacks; it is fair to assume that some admixture of white blood obtained throughout the group of American negroes examined. What influence can this white strain have had in bringing out the single case of supracondyloid process in the group of 1000 blacks? The individual who bore the processes (very small bilateral spurs) exhibited in his bodily proportions evidences of the influence of white ancestry.[4] Under these circumstances a diagnosis of the presence of the supracondyloid process in the negro cannot be claimed with a high degree of conviction. On the other hand allowance must be made for the possible failure to detect a small process by the method of palpation. What is of greater weight, however, for the expectation of this exuberant form of the variation occurring in a larger group of negro subjects is the presence of the less developed forms which I have discovered in a small series of arm bones. Fifty-two humeri of negroes (mostly native Africans) in the collection of the United States National Museum[5] presented the following conditions relative to the supracondyloid variation: in 33 bones there was no trace of the

[4]Terry, *ibid.*

[5]It is a pleasure to acknowledge the many courtesies extended to the writer by Dr. Hrdlička while the writer was a guest of the Division of Physical Anthropology of the National Museum during the summer of 1922.

variation (65.39%); in 3 there was a rough spot at the site of the variation; in 15 there was a ridge more or less pronounced; in 1 a medium sized tubercle; i.e. the supracondyloid variation was represented in 34.61% of the series. Not wishing to press the details of this sample series into comparison, let it be remarked that the frequency of all forms of the supracondyloid variation together, 34.61 per cent, gives an interesting contrast, in the light of the results of the examination of the living, with the incidence of all forms of the variation observed by Hrdlička in a large number of humeri of white subjects, viz., 63.8 per cent.

From a study of a series of arm bones of negroes, evidence of the supracondyloid variation was discovered; the incidence from this sample is markedly lower than that determined for the variation in the arm bones of whites. By the method of palpation of the arm in the living it appeared that the frequency of the supracondyloid process in the group of American negroes was about one-twelfth of the incidence in the group of whites.

INCIDENCE OF THE SUPRACONDYLOID PROCESS IN WHITES AND OTHER RACES

ALEŠ HRDLIČKA

Between the year 1896 when the writer commenced work on the then beginning Huntington collection (now in the U. S. National Museum), and the present day, he has examined and measured large numbers of humeri of different races and one of the points to which attention was paid was the occurrence of the supracondyloid process. Since Dr. Terry's and his associates' work on this feature, these data which have not yet been published have become of greater interest and it seems advisable to make them more generally available; they are therefore briefly here given.

In the course of the observations it was seen that the site from which the process generally arises showed a variety of conditions. In numerous specimens, particularly in the young, this part of the medial anterior surface of the bone was entirely smooth or very nearly so; in others there would be on the spot a distinct to pronounced roughness, a slight to marked oblong elevation, a slight to very marked ridge, one or even more tubercles, and finally a variously formed spine above 2 mm. in height, which could properly be called a "process."

A large number of humeri were examined with special care, all the above manifestations being separately recorded. This study made it plain that all these forms are homologous. They are all indications of the supracondyloid process or rather arch, even though they seldom attain sufficient development to be called a process.

A strange phenomenon which appeared early in these studies and has since proved constant is on one hand the rarity of the above mentioned manifestations especially in their more pronounced form in early man, in primitive races, and in the anthropoid as well as in many of the lower apes; and on the other hand their relative frequency in the Whites of the present day. It would seem that this ancestral feature which became almost wholly eliminated before man or even the higher

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Primates were reached in the process of evolution, is for some reason or reasons reasserting itself in the modern white man. If this is so—and there appears to be no other explanation of the facts—then we are confronted with the most interesting demonstration of, on one side, the great tenacity of a feature that was already almost eliminated, and on the other of a tendency towards the reappearance of this feature under some conditions of modern life which we do not as yet well understand. That the supracondyloid process in man actually represents the supracondyloid bony arch as found to-day in some of the rodents, carnivora etc. as well as in some of the Prosimiae and various lower apes such as some of the Cercopithecidae and especially Cibidae is not subject to doubt; the process is often prolonged to an arch by a fibrous band, and there is known actually at least one complete bony arch in a human subject (Dwight, Harvard Medical Museum).

As to the data presented below, they need but little comment. The process does not apparently occur with the same frequency in all Whites; it is just about ten times more frequent in the Whites than in the American Indians; it appears to be as common in the Eskimo as in the White, but the number of bones of the former was hardly sufficient definitely to establish this point; and though several hundreds of humeri of Negroes, Melanesians and Australians were examined, there was found nothing that could be called a plain process among them.[1]

As to sex, the supracondyloid process appears to be more common in the females than in the males, which would well agree with our knowledge of the greater conservatism of past conditions in the female.

As to side the differences are not very material. Age, on the other hand, is a very important factor. The humeri of children and young, while they may present a full-fledged process (a few such cases have been observed)[2] show far less than adult bones of the secondary manifestations (roughness, oblong elevations, ridge, tubercle on the site of the process).

[1] According to Terry (this no. of this JOURNAL) in the American negro the incidence of the process is about one-twelfth of that in the Whites.

[2] Cunningham (D. J.)—Supracondyloid Process in the Child. *J. Anat. & Physiol.* XXXIII, 1899, p 357. (See also his Textbook of Anatomy, 1902). Also Supracondyloid Process in the Child—Unsigned edit. note, *J. Anat. & Physiol.*, XXXIII, Oct. 1898, p. 212; and other publications.

Frequency of Supracondyloid Process and Its Traces According To Sex, in Whites

	Males						*Females*					
	United States	Ireland	Germany	Italy	Miscell.	All	United States	Ireland	Germany	Italy	Miscell.	All
Bones examined in detail	(473)	(220)	(267)	(165)	(310)	(1435)	(180)	(197)	(64)	(40)	(94)	(575)
						Per cent						*Per cent*
No trace	32.1	33.2	34.5	46.7	39.4	*30.6*	47.8	36.5	39.1	42.5	41.5	*41.6*
Slight roughness	18.2	26.4	19.5	18.8	21.–	*20.3*	18.3	17.3	15.6	22.5	23.4	*18.8*
Moderate roughness	4.2	5.–	4.1	3.6	3.9	*4.2*	3.9	3.–	3.1	2.5	3.2	*3.3*
Prominent roughness	—	1.4	1.1	—	0.3	*0.5*	—	—	—	—	—	—
Sl. oblong elevation	11.8	8.6	12.–	11.5	9.7	*10.9*	7.8	12.2	10.9	12.5	8.5	*10.1*
Prominent obl. elevation	4.7	5.–	4.9	3.6	5.5	*4.8*	1.1	5.6	6.2	—	—	*3.–*
Sl. ridge, long	16.7	11.8	14.6	8.5	10.6	*13.3*	13.9	11.7	12.5	7.5	8.5	*11.6*
Mod. rdg. long	8.7	2.3	6.4	4.2	4.5	*5.9*	2.8	4.1	6.2	7.5	10.6	*5.2*
Small tubercle	0.8	3.6	2.2	1.8	2.6	*2.–*	0.6	6.5	1.6	2.5	—	*2.6*
Tub. bet. 1 & 3 mm. high	1.–	—	0.7	—	0.3	*0.6*	1.1	2.5	4.7	—	1.1	*1.9*
Process above 3 mm	1.3	1.4	—	—	1.–	*0.85*	2.8	1.–	—	2.5	3.2	*1.9*
Special	0.4	1.4	—	1.2	1.3	*0.8*	—	—	—	—	—	—
All Humeri	(877)	(373)	(431)	(202)	(426)	*(2309)*	(329)	(349)	(108)	(58)	(144)	*(988)*
Process above 3 mm. on total no. of bones examined	*1.03*	*1.34*	—	—	*0.94*	*0.78*	*1.8*	*0.57*	—	*1.72*	*2.08*	*1.21*

Supracondyloid Process and Its Traces, According to Side, in Whites

	Males Right	*Males* Left	*Females* Right	*Females* Left
	percent	percent	percent	percent
No trace	37.8	34.–	42.7	40.4
Slight roughness	20.7	20.–	18.3	19.3
Moderate roughness	4.4	4.–	4.5	2.1
Prominent roughness	0.55	0.4	—	—
Slight oblong elevation	8.8	13.–	10.–	10.–
Prominent oblong elevation	3.7	6.–	3.1	2.8
Slight ridge, long	12.5	14.2	9.6	13.7
Moderate ridge, long	6.3	5.4	4.5	6.–
Small tubercle	2.3	1.7	2.4	2.8
Tubercle between 1 & 3 mm. high	1.1	0.4	2.7	1.–
Process, above 3 mm	1.–	0.3	2.1	1.7
Special	1.–	0.6	—	—
Bones examined in detail	(730)	(705)	(290)	(285)
All bones examined	(1185)	(1123)	(497)	(491)
Supracondyloid Process	*0.99*	*0.62*	*1.21*	*1.22*

Descriptive Notes. The processes (supracondyloid) encountered on the arm bones of Whites were as follows:

Males:

1.	U. S.,	right–	4 mm.high,	7 cm.	above the lower border of the internal condyle
2.	"	"	20 " "	6.7 "	" " " " " " " "
3.	"	"	4 " "	5.7 "	" " " " " " " "
4.	"	"	4 " "	4.8 "	" " " " " " " "
5.	"	"	9 " "	3.– "	" " upper " " " anterior fossa[1]
6.	"	left	3 " "	4.4 "	" " " " " " " "
7.	"	"	11 " "	3.2 "	" " " " " " " "
8.	"	"	4 " "	4.– "	" " " " " " " "
9.	"	"	3 " "	3.8 "	" " " " " " " "
10.	Ireland	right	3 " "	4.– "	" " " " " " " "
11.	"	"	3 " "	3.3 "	" " " " " " " "
12.	"	"	9 " "	4.– "	" " " " " " " "
13.	"	"	5 " "	5.2 "	" " " " " " " "
14.	"	left	5 " "	4.– "	" " " " " " " "
15.	Misc.	right	3 " "	4.1 "	" lower " " " internal condyle
16.	"	"	4 " "	6.6 "	" " " " " " " "
17.	"	left	11 " "	6.4 "	" " " " " " " " (paired with preceding)
18.	"	"	7 " "	4.– "	" " upper " " " anterior fossa.

Females:

1.	U. S.,	right–	9 mm. high,	4.9 cm.	above the lower border of the internal condyle
2.	"	"	14 " "	4.5 "	" " " " " " " "
3.	"	"	5 " "	6.3 "	" " " " " " " "
4.	"	left	17 " "	4.3 "	" " " " " " " "
5.	"	"	5 " "	3.3 "	" " upper border of the anterior fossa
6.	"	"	4 " "	3.5 "	" " " " " " " "
7.	Ireland,	right	3 " "	2.7 "	" " " " " " " "
8.	"	left	5 " "	3.– "	" " " " " " " "
9.	Italy	"	3 " "	4.– "	" " " " " " " "
10.	Misc.	right	3 " "	3.5 "	" " " " " " " "
11.	"	"	4 " "	4.2 "	" " " " " " " "
12.	"	left	5 " "	3.2 "	" " " " (paired with preceding).

The "special" cases and the tubercles include the following specially interesting conditions: (1) U. S. male, right,—two small rough tubercles on the site of the process; (2) U. S. male, right,—ridge 4.8 cm. long, 4 mm. high at maximum; (3) U. S. male, left,—a very long ridge; (4) U. S. male, left,—a moderate oblong elevation with a 1.5 mm. high tubercle; (5) Ireland, male right—moderate ridge with a small tubercle; (6) Ireland, male, right—a pronounced, irregular, oblong elevation; (7) Italy, male, right—ridge 4 cm. long, 3 mm. high at max.; (8) Italy, male, left (paired with preceding)—ridge 4 cm. long, 3 mm. high;(9) White, left—six small tubercles in a vertical line on site of process.

[1]Measurement from the uppermost part of the border of the anterior fossa gives more uniform results, but due to damage and occasional indistinctness of the upper border of the fossa is not always feasible. Also the process is more vertical above the condyle.

The remainder of the cases falling into these two categories are especially pronounced ridges or simple tubercles not exceeding 2 mm. in height.

SUPRACONDYLOID PROCESS: INCIDENCE OF, IN INDIANS

Total number of Indian humeri examined, 3094; bone smooth (or nearly so) in the locality of the process, 2146; 69.4%—approximately seventy percent; slight to plain roughness in the locality of the process, 305; 9.8%—approximately ten percent; slight to moderate ridge in the locality of the process, 608; 19.7%—approximately twenty percent; marked ridge in the locality of the process, 27; 0.87%—approximately seventeen percent; small tubercle in the locality of the process, 5; 0.16%—one & five-tenths per thousand; supracondyloid process present in 3[1]; 0.097%—approximately one per thousand.

SUPRACONDYLOID PROCESS IN INDIAN CHILDREN AND YOUNG

Humeri examined	323		
Bones smooth (or very nearly so) in the locality of the process	310	or	*96.*– percent
Slight to moderate oblong elevation or ridge on the site	11	"	*3.4* "
Marked oblong elevation	2	"	*0.6* "

SUPRACONDYLOID PROCESS IN ESKIMO

Humeri examined	128		
Bones smooth (or very nearly so) in the locality of the process	78	or	*60.9* percent
Slight to moderate oblong elevation or ridge on the site	43	"	*33.6* "
Marked oblong elevation	5	"	*3.9* "
Supracondyloid process	2[1]	"	*1.6* "

[1]1-slight process on moderate ridge
1-5 mm. high process—not mate with preceding.

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MENTAL FORAMEN IN THE ANTHROPOIDS AND IN MAN[1]

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LOCATION OF MENTAL FORAMINA

A study of the variation in position of an anatomical feature, such as the mental foramen, involves the difficulty that all anatomical characters are variable and locations must be made with reference to more or less arbitrarily assigned landmarks. For these observations the mental foramen is located in reference to the teeth. (Fig. 1[2]).

Gorillas

ANTERO-POSTERIOR POSITION

In line with the lower first bicuspid—3
Between the lower first and second bicuspids—6
Slightly anterior to the lower second bicuspids—9
In line with the lower second bicuspid—18
Slightly posterior to the lower second bicuspid—3
Between the lower second bicuspid and the mesial root of the lower first molar—2
In line with the mesial root of the lower first molar—1
Between the mesial and distal roots of the lower first molar—1

It will be noted that the most constant position of the foramen in the gorilla is in line with the lower second bicuspid. This location was found in 41 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally summetrical—8 pairs; not bilaterally symmetrical—12 pairs. Bilateral symmetry occurred in 40 per cent of the cases.

[1]For access to the specimens of the group of California Indians, the author is indebted to Professor E. W. Gifford, Associate Curator of the Museum of Anthropology, University of California. The observations for the other groups were made on the collections of the Division of Physical Anthropology and Mammalogy, U. S. National Museum, Smithsonian Institution.

[2]Sketches made from specimen in group of California Indians. For significance of numbers on sketch see California group.

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MULTIPLE FORAMINA

Three foramina—6 cases; two foramina—6 cases; one foramen—31 cases. Multiple foramina (two or three foramina) occurred in 27 per cent of the cases.

Occasionally the orificial expansion of the foramen was penetrated by numerous canals.

A tendency to three foramina arranged in an equilateral triangle was rather marked in the gorilla.

Orangs

ANTERO-POSTERIOR POSITION

Slightly anterior to lower first bicuspid—3
In line with the lower first bicuspid—4
Slightly posterior to the lower first bicuspid—8
Between the lower first and second bicuspids—11
Slightly anterior to the lower second bicuspid—34
In line with the lower second bicuspid—45
Slightly posterior to the lower second bicuspid—14
Between the lower second bicuspid and the mesial roots of the lower first molar—2
Between the mesial and distal roots of the lower first molar—2

The most constant position of the foramen in the orangs is in line with the lower second bicuspid. This location was made in 36 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally symmetrical—28 pairs; not bilaterally symmetrical—33 pairs. Bilateral symmetry occurred in 45 per cent of the cases.

MULTIPLE FORAMINA

Four foramina—1; three foramina—7; two foramina—40; one foramen—75. Multiple foramina occurred in 39 per cent of the cases.

Occasionally the orificial expansion of the foramen was penetrated by two canals. Occasionally it was perforated by several openings.

A tendency to three foramina arranged in a triangle, which was rather marked in the gorilla, only occurred rarely in the orang.

Chimpanzees

ANTERO-POSTERIOR POSITION

Between the lower first and second bicuspids—4
Slightly anterior to the lower second bicuspid—2

In line with the lower second bicuspid—16
Slightly posterior to the lower second bicuspid—1
Between the lower second bicuspid and lower first molar—7
In line with mesial root of lower first molar—2

The most constant position of the foramen in the chimpanzee is in line with the lower second bicuspid. This location was noted in 50 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally symmetrical—10 pairs; not bilaterally symmetrical—4 pairs. Bilateral symmetry occurred in 71 per cent of the cases.

MULTIPLE FORAMINA

Three foramina—1 case; two foramina—4 cases; one foramen—27 cases. Multiple foramina occurred in 15 per cent of the cases.

Human—Whites

ANTERO-POSTERIOR POSITION

Slightly anterior to lower first bicuspid—1
In line with lower first bicuspid—2
Slightly posterior to lower first bicuspid—13
Between the lower first and second bicuspids—26
Slightly anterior to the lower second bicuspid—29
In line with the lower second bicuspid—46
Slightly posterior to the lower second bicuspid—14
Between the lower second bicuspid and the mesial root of the lower first molar—7

The most constant position of the foramen is in line with the lower second bicuspid. This location was recorded in 33 per cent of the cases.

BILATERAL SYMMETRY

Bilateral symmetrical—27 pairs; not bilaterally symmetrical—37 pairs. Bilateral symmetry occurred in 42 per cent of the cases.

MULTIPLE FORAMINA

Two foramina—9 cases; one foramen—129 cases. Multiple foramina occurred in 6 per cent of the cases.

Kentucky Indians

ANTERO-POSTERIOR POSITION

Slightly posterior to the lower first bicuspid—5
Between the lower first and second bicuspids—20

9 In line with lower first bicuspid—2
8 Slightly posterior to lower first bicuspid—27
7 Between lower first and lower second bicuspids—29
6 Slightly anterior to lower second bicuspid—129
5 In line with lower second bicuspid—102
4 Slightly posterior to lower second bicuspid—40
3 Between lower second bicuspid and mesial root of lower first molar—6.
2 Slightly anterior to mesial root of lower first molar—0
1 In line with mesial root of lower first molar—1

The most constant position is slightly anterior to lower second bicuspid. This location was seen in 37 per cent of the cases. The position "in line with the second bicuspid" occurred in 30 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally symmetrical—91 pairs; not bilaterally symmetrical—64 pairs. Bilateral symmetry occurred in 29 per cent of the cases.

MULTIPLE FORAMINA

Two foramina—8; one foramen—334. Multiple formina occurred in 2 per cent of the cases.

SUPERO-INFERIOR POSITIONS

Number on
Sketch, Fig. 2.

1 Considerably below the level of the apices of the bicuspids—10
2 Below the level of the apices of the bicuspids—226
3 Slightly below the apices of the bicuspids—31
4 At about the level of the apices of the bicuspids—40
5 At the level of the apices of the bicuspids—9
7 Considerably below the level of the apices of the first molar—2
8 Below the level of the apices of the first molar—5

Between *5* and *6* Slightly above the level of the apices of the bicuspids—1

6 Above the level of the apices of the bicuspids—12

Sizes of Foramina

Figs. 5 A, 5 B, 5 C, 5 D.

Very large—1; large—11; medium—180; small—148; quite small—1; very small—1.

Negroes

ANTERO-POSTERIOR POSITION

In line with lower first bicuspid—1
Slightly posterior to lower first biscupid—1
Between the lower first and second bicuspids—4
Slightly anterior to the lower second bicuspid—6
In line with lower second bicuspid—12
Between lower second bicuspid and mesial root of the lower first molar —12
In line with the mesial root of the lower first molar—4
Between the apices of the mesial and distal roots of the lower first molar —2

The most constant position of the foramen in the negroes is in line with the lower second bicuspid. This location was made in 28 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally symmetrical—13 pairs; not bilaterally symmetrical—8 pairs. Bilateral symmetry occurred in 61 per cent of the cases.

MULTIPLE FORAMINA

Three foramina—1; two foramina—6; one foramen—35. Multiple foramina occurred in 16 per cent of the cases.

Melanesians

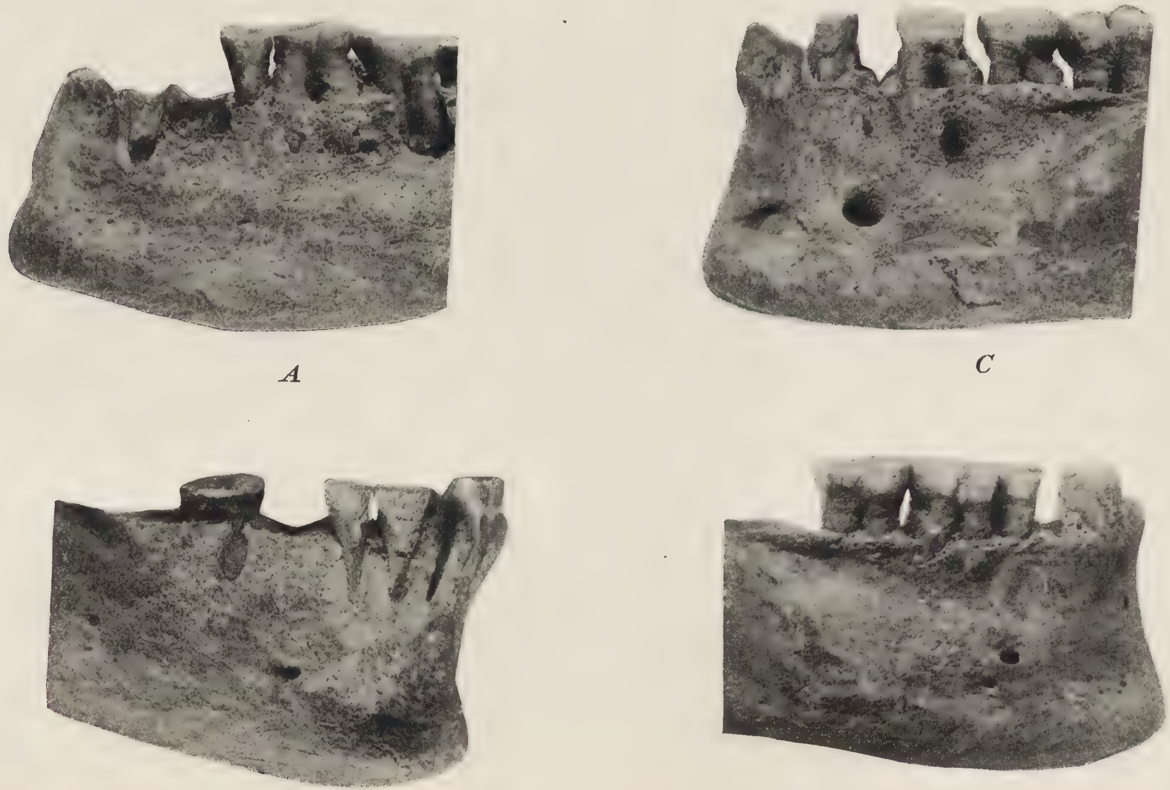
ANTERO-POSTERIOR POSITION

Slightly posterior to lower second bicuspid—1
Between lower first and second bicuspids—1
Slightly anterior to the lower second bicuspid—10
In line with the lower second bicuspid—15
Slightly posterior to the lower second bicuspid—7
Between the lower second bicuspid and mesial root of lower first molar —21
In line with the mesial root of the lower first molar—3

The most constant position was between the lower second bicuspid and mesial root of lower first molar. This location was made in 36 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally symmetrical—14 pairs; not bilaterally symmetrical—15 pairs. Bilateral symmetry occurred in 48 per cent of the cases.



A C B D

Pl. I. The more common variations in the Mental Foramen in Man
A—very small; *B*—medium; *C*—large; *D*—double

MULTIPLE FORAMINA

Two foramina—6; one foramen—52. Multiple foramina occurred in 11 per cent of the cases.

Japanese

ANTERO-POSTERIOR POSITIONS

Slightly anterior to lower second bicuspid—3
In line with lower second bicuspid—4
Between lower second bicuspid and mesial root of lower first molar—3

The most constant position was in line with the lower second bicuspid. This location was made in 40 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally symmetrical—3 pairs; not bilaterally symmetrical—2 pairs. Bilateral symmetry occurred in 60 per cent of the cases.

MULTIPLE FORAMINA

There were no multiple foramina.

Eskimo

ANTERO-POSTERIOR POSITIONS

In line with the lower first bicuspid—2
Slightly posterior to the lower first bicuspid—5
Between the lower first and second bicuspids—17
Slightly anterior to the lower second bicuspid—18
In line with the lower second bicuspid—50
Slightly posterior to the lower second bicuspid—10
Between the lower second bicuspid and mesial root of lower first molar—11
In line with the mesial root of the lower first molar—1

The most common position of the foramen in the Eskimo is in line with the lower second bicuspid. This location was made in 43 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally symmetrical—27 pairs; not bilaterally symmetrical—27 pairs. Bilateral symmetry occurred in 50 per cent of the cases.

MULTIPLE FORAMINA

Two foramina—10; one foramen—104. Multiple foramina occurred in 8 per cent of the cases.

Egyptians

ANTERO-POSTERIOR POSITIONS

In line with lower first bicuspid—1
Slightly posterior to lower first bicuspid—5
Between lower first and second bicuspid—11
Slightly anterior to lower second bicuspid—33
In line with the lower second bicuspid—42
Slightly posterior to the lower second bicuspid—32
Between the lower second bicuspid and mesial root of lower first molar —25
In line with the mesial root of the lower first molar—11

The most constant position is in line with the lower second bicuspid. This location exists in 26 per cent of the cases.

BILATERAL SYMMETRY

Bilaterally symmetrical—31; not bilaterally symmetrical—47. Bilateral symmetry occurs in 39 per cent of the cases.

MULTIPLE FORAMINA

There are no multiple foramina.

Conclusions

The considerable differences in the numbers of specimens examined in the various groups makes it difficult to draw definite conclusions. Much of the data given is nevertheless of interest, both to the dentist and the morphologist. The most important tendencies are:

1. *Tendency for the foramen to lie in line with the lower second bicuspid.* This was the case in all the groups except the Melanesians and the California Indians. The percentage of foramina occurring in line with the lower second bicuspid in the various groups are:

Group	% of Foramina Posterior to Lower Second Bicuspid	Group	% of Foramina Posterior to Lower Second Bicuspid
Arkansas Indians	72%	Japanese	40%
Kentucky Indians	56%	Orangs	36%
Chimpanzees	50%	Whites	33%
Eskimos	43%	Negroes	28%
Gorillas	41%	Egyptians	26%

2. Tendency for the foramen to be placed posteriorly, i. e., posterior to the lower second bicuspid. This tendency varies as follows:

Group	% of Foramina Posterior to Lower Second Bicuspid	Group	% of Foramina Posterior to Lower Second Bicuspid
Melanesians	53%	Arkansas Indians	17%
Negroes	42.8%	Gorilla	16.2%
Egyptians	42.5%	Kentucky Indians	16%
Chimpanzees	31%	Orang	15.92%

Japanese	30%	Whites	15.2%
Eskimo	19%	California Indians	13%

3. Tendency to multiple foramina. Multiple foramina occur in the following percentage of cases in the various groups:

Orangs	39	Melanesians	11	California Indians	2
Gorilla	27	Eskimo	8	Japanese[1]	0
Negroes	16	Whites	6	Egyptians	0
Chimpanzees	15	Kentucky Indians	5		

A tendency to the occurrence of three foramina arranged in the form of an equilateral triangle is rather noticeable in the gorilla, rare in the orang and was not observed in the other groups.

[1]Only a very small number of specimens of Japanese observed.

VARIATION IN THE DIMENSIONS OF LOWER MOLARS IN MAN AND ANTHROPOID APES

ALEŠ HRDLIČKA

In connection with his study of the Piltdown teeth the writer undertook the measurement of a large series of well preserved lower molars, both human and of the anthropoid apes. In the main the results have already been published;[1] but in the analysis of the data there came out a number of interesting points which could not be used or could merely be touched upon, in the articles that have already appeared in print. These points, some of which are apparently of more than passing interest, will be briefly reported in this paper. They relate to the teeth of modern man and to those of the living great apes.

MAN

The extensive and well identified collections of the U. S. National Museum, both human and comparative, made it possible to obtain fairly ample series of lower jaws of both sexes, with well preserved M_1 and M_2 on the two sides.[2] The result of this is that, for the first time in the history of tooth measurements, we have an approach to fair averages, and that it is possible to show differences in the teeth as to sex and side.[3]

So far as man is concerned, the utilized material represents six racial groups and consists of 40 jaws of American Whites (of various derivation) 30 jaws of old Egyptians (of approximately 2000 B. C.), 100 jaws of North American Indians (partly recent, partly precolumbian), 40 jaws of Eskimo (mainly western and St. Lawrence Island), 20 jaws of African and American negroes, and 20 jaws of Melanesians (mainly New Britain). The main results are, in brief, as follows:

[1]This *Journal*, 1922, V, No. 4; 1923, VI, No. 2.
[2]Due to its great variability and in man more or less frequent absence, the third molar had to be left out of these studies.
[3]For previous measurements and bibliography as well as method and nomenclature, see this *Journal*, 1923, VI, No. 2.

RACE

As to size of the teeth, the records are rather sharply divided into two groups—on one side the whites and the Egyptians, on the other the yellow-browns and blacks. Taking the module or mean diameter $\frac{(L+B)}{(2)}$ of the teeth we find the following conditions:

M_1 Male	M_1 Female	M_2 Male	M_2 Female
10.51—Egyptians	10.24—Egyptians	10.31—Egyptians	10.07—Whites
10.53—Whites	10.46—Whites	10.32—Whites	10.08—Egyptians
11.03—Negroes	10.69—Negroes	10.77—Negroes	10.30—Indians
11.13—Eskimo	10.78—Indians	10.84—Melanesians	10.41—Melanes's
11.24—Melanesians	10.99—Eskimo	10.93—Indians	10.57—Negroes
11.28—Indians	11.15—Melanesians	10.95—Eskimo	10.63—Eskimo

The smallest teeth are those of the Egyptians and the whites. The former were prevalently men and women of the higher classes buried in deep shafts in stone about the pyramid of the first pharaoh of the XII dynasty; the whites were those of the American lower classes (dissecting room material). The closeness of the two groups, amounting to identity in the second molar, is very remarkable and is another strong indication of the derivation of the Egyptians from the white stock.

Among the colored groups conditions are more irregular both as to tooth and sex. The African negro has on the whole slightly smaller teeth than either the Indian, the Eskimo or the Melanesian. If we take the mean module of the four teeth in each of the groups, we obtain: Negro—10.76; Indian—10.82; Melanesian—10.91; Eskimo—10.93. The largest molar mass is therefore found in the Eskimo, which agrees with what we know of the demands he makes upon his teeth.

The crown index is remarkably close in all the larger racial groups; occasionally however this holds less true for some smaller group as we shall see further on. Taking the mean index of all the teeth and in both sexes together, in the several groups, we obtain the following scale: Whites—96.8; Egyptians—97.2; Melanesians—97.4; Indians—97.7; Eskimo—97.9; Negro—97.9. These are small differences and it is hard to attach to them any special significance. Somewhat more marked variance will be seen in the separate teeth and between the two sexes.

INDIAN TEETH

Some highly interesting conditions were revealed by the teeth of the American Indian. The 50 male and 50 female jaws of this series were

VARIATION IN DIMENSIONS OF FIRST AND SECOND LOWER MOLARS: MAN

			Males						Females					
1st MOLAR			Whites U. S.	Egyptians (XII Dyn)	Indians[1] U. S.	Eskimo	Negro African & U. S.	Melanesians	Whites (U.S.)	Egyptains (XII Dyn)	Indians[1] U. S.	Eskimo	Negroe African & U. S.	Melanesians
			(20)	(20)	(30)	(20)	(10)	(10)	(20)	(10)	(30)	(20)	(10)	(10)
			mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
RIGHT	Length	Av.	**10.60**	**10.61**	**11.41**	**11.28**	**11.20**	**11.30**	**10.78**	**10.40**	**11.—**	**11.17**	**11.05**	**11.57**
		Min.	9.5	9.5	10.—	10.5	10.—	10.5	10.—	10.—	9.5	10.5	10.—	11.—
		Max.	12.5	11.2	12.5	12.5	12.5	12.—	11.5	11.5	12.5	12.—	12.—	12.—
	Breadth	Av.	**10.51**	**10.39**	**11.13**	**11.02**	**10.95**	**11.07**	**10.11**	**10.10**	**10.58**	**10.76**	**10.55**	**10.77**
		Min.	9.—	10.—	10.—	10.5	10.—	10.5	9.5	9.3	9.8	10.	9.5	9.5
		Max.	12.—	11.—	12.5	11.5	12.—	12.—	11.—	11.2	11.8	12.—	11.5	11.5
	L-B Index	Av.	**99.2**	**97.9**	**97.5**	**97.7**	**97.8**	**98.—**	**93.9**	**97.1**	**96.2**	**96.4**	**95.5**	**93.1**
		Min.	*93.6*	*90.9*	*87.—*	*91.7*	*90.9*	*91.7*	*86.4*	*90.9*	*89.6*	*90.9*	*90.5*	*86.4*
		Max.	*105.3*	*110.5*	*110.–*	*104.8*	*105.–*	*115.–*	*100.–*	*105.–*	*104.8*	*100.–*	*100.–*	*100.–*
LEFT	L	Av.	**10.50**	**10.64**	**11.43**	**11.14**	**11.10**	**11.35**	**10.78**	**10.27**	**10.91**	**11.16**	**10.85**	**11.47**
		Min.	9.5	10.—	10.—	10.—	10.—	10.5	10.—	9.5	9.5	10.5	9.5	10.5
		Max.	12.—	11.—	13.—	12.5	12.5	12.—	11.5	11.—	12.—	12.—	12.—	12.—
	B	Av.	**10.52**	**10.42**	**11.17**	**11.08**	**10.85**	**11.22**	**10.13**	**10.19**	**10.64**	**10.87**	**10.40**	**10.79**
		Min.	9.—	10.2	10.—	10.—	10.—	10.2	9.5	9.7	9.5	10.—	9.—	9.5
		Max.	12.—	11.—	12.5	11.5	12.—	12.—	11.—	11.2	11.8	12.—	11.—	11.5
	I	Av.	**100.1**	**98.—**	**97.7**	**99.5**	**97.7**	**98.9**	**94.—**	**99.2**	**97.5**	**97.4**	**95.8**	**94.1**
		Min.	*90.9*	*92.7*	*87.—*	*90.4*	*90.9*	*91.7*	*86.4*	*90.9*	*90.9*	*91.7*	*90.—*	*90.5*
2nd MOLAR		Max.	*105.3*	*105.–*	*104.8*	*110.–*	*105.–*	*114.3*	*100.–*	*110.5*	*104.8*	*104.3*	*105.3*	*98.2*
RIGHT	L	Av.	**10.39**	**10.54**	**11.04**	**11.11**	**10.85**	**10.95**	**10.32**	**10.30**	**10.35**	**10.78**	**10.60**	**10.45**
		Min.	9.—	9.5	9.—	9.5	10.—	10.5	9.—	9.5	9.—	10.—	9.5	9.5
		Max.	12.5	11.—	13.5	12.—	12.—	12.—	11.5	11.5	12.—	12.—	12.—	11.5
	B	Av.	**10.28**	**10.05**	**10.80**	**10.84**	**10.70**	**10.75**	**9.80**	**9.83**	**10.14**	**10.48**	**10.55**	**10.32**
		Min.	8.5	9.3	9.8	9.5	9.5	9.5	8.5	9.—	9.—	9.5	9.8	8.5
		Max.	12.—	11.—	12.—	12.—	12.—	11.5	11.—	11.2	11.5	12.—	11.5	11.5
	I	Av.	**98.9**	**95.3**	**97.8**	**97.3**	**98.7**	**98.2**	**95.—**	**95.4**	**98.0**	**97.2**	**99.5**	**98.8**
		Min.	*88.7*	*86.1*	*88.9*	*90.9*	*91.7*	*86.4*	*81.8*	*86.4*	*91.7*	*87.5*	*91.7*	*89.5*
		Max.	*106.7*	*105.3*	*111.1*	*104.5*	*105.–*	*110.–*	*100.–*	*100.–*	*107.8*	*104.8*	*105.3*	*104.7*
LEFT	L	Av.	**10.42**	**10.51**	**11.03**	**11.—**	**10.80**	**10.85**	**10.35**	**10.21**	**10.44**	**10.68**	**10.60**	**10.52**
		Min.	9.—	9.5	9.—	9.5	9.5	10.—	9.—	9.5	9.—	9.7	9.5	9.5
		Max.	12.5	11.—	13.5	12.—	12.5	12.—	11.5	11.—	12.—	12.—	12.—	11.5
	B	Av.	**10.23**	**10.16**	**10.84**	**10.85**	**10.73**	**10.80**	**9.84**	**9.98**	**10.27**	**10.58**	**10.53**	**10.34**
		Min.	8.5	9.5	10.—	9.5	9.5	9.5	8.5	9.1	9.—	9.5	9.8	8.5
		Max.	12.—	11.5	12.—	11.8	12.5	11.5	11.—	11.—	11.5	12.—	11.2	11.5
	I	Av.	**98.2**	**96.7**	**98.3**	**98.7**	**99.2**	**99.5**	**95.1**	**97.7**	**98.4**	**99.1**	**99.3**	**98.6**
		Min.	*88.7*	*87.3*	*88.9*	*91.3*	*95.2*	*86.4*	*86.4*	*88.2*	*90.—*	*89.2*	*91.7*	*89.5*
		Max.	*112.–*	*104.6*	*111.1*	*104.8*	*105.–*	*111.–*	*100.–*	*104.8*	*105.7*	*105.–*	*105.3*	*104.7*

[1]10 each of Sioux, Arkansas and Pueblo.

especially marked by the fine preservation of the denture. The observations extend to four representative North American groups, three precolumbian and one (the Sioux) recent. The Kentucky tribe belonged, according to indications given by the skulls, to the Algonquins.

VARIATION IN DIMENSIONS OF FIRST AND SECOND LOWER MOLARS: INDIANS

			Males				Females		
			(Ky.)	Sioux	Pueblos	Arkansas	(Ky.)	Sioux	Pueblos	Arkansas
1st MOLAR			(20)	(10)	(10)	(10)	(20)	(10)	(10)	(10)
			mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Right	Length	Av.	10.63	11.66	11.10	11.48	10.89	11.30	10.68	11.02
		Min.	9.5	11.—	10.—	10.5	9.—	10.5	9.5	10.5
		Max.	11.5	12.2	12.—	12.5	12.—	12.5	11.8	11.5
	Breadth	Av.	11.31	11.35	10.95	11.10	10.93	10.87	10.11	10.76
		Min.	10.5	10.—	10.—	10.—	10.—	10.—	9.8	10.2
		Max.	12.0	12.5	12.—	12.5	12.—	11.8	11.—	11.—
	L-B Index	Av.	106.4	97.3	98.6	96.7	100.4	96.1	94.7	97.6
		Min.	97.3	90.9	87.—	90.9	90.9	89.6	90.1	93.9
		Max.	120.–	102.5	110.–	100.–	116.7	104.8	100.2	100.–
Left	L	Av.	10.48	11.76	11.17	11.36	10.88	11.27	10.50	10.97
		Min.	9.5	11.—	10.—	10.5	9.—	10.5	9.5	10.5
		Max.	11.5	13.—	12.—	12.5	12.—	12.—	11.5	11.5
	B	Av.	11.33	11.42	10.95	11.15	10.95	10.98	10.13	10.80
		Min.	10.5	10.—	10.—	10.—	10.—	10.—	9.5	10.5
		Max.	12.—	12.5	12.—	12.5	12.—	11.8	11.—	11.2
	I	Av.	108.1	97.1	98.—	98.1	100.7	97.4	96.5	98.7
		Min.	100.–	90.9	87.—	93.2	90.9	91.7	90.9	95.4
		Max.	120.–	102.5	104.8	104.8	116.7	104.8	102.–	101.8
2nd MOLAR										
Right	L	Av.	10.6	11.60	10.50	11.02	10.26	10.98	9.60	10.47
		Min.	8.5	10.5	9.—	10.—	9.—	10.5	9.—	10.—
		Max.	12.—	13.5	11.5	11.5	11.—	12.—	11.—	11.—
	B	Av.	11.14	11.16	10.45	10.79	10.54	10.53	9.59	10.30
		Min.	10.5	10.—	10.—	9.8	9.5	10.—	9.—	10.—
		Max.	12.5	12.—	11.5	11.5	11.5	11.5	10.5	11.2
	I	Av.	105.1	96.2	99.5	97.9	102.2	95.9	99.9	98.4
		Min.	100.–	88.9	90.9	91.3	93.—	91.7	94.7	93.6
		Max.	123.5	104.8	111.1	100.–	116.7	100.—	105.3	107.8
Left	L	Av.	11.43	11.60	10.55	10.94	10.3	10.98	9.80	10.54
		Min.	8.5	10.5	9.—	10.—	9.—	10.5	9.—	10.—
		Max.	11.5	13.5	11.5	11.5	11.—	12.—	11.—	11.5
	B	Av.	11.17	11.26	10.48	10.80	10.52	10.68	9.74	10.39
		Min.	10.5	10.—	10.—	10.—	9.5	10.—	9.—	10.—
		Max.	12.—	12.—	11.5	11.5	11.5	11.5	11.—	11.5
	I	Av.	107.1	97.1	99.3	98.7	102.2	97.3	99.4	98.6
		Min.	95.4	88.9	90.9	91.3	90.—	90.—	90.5	95.4
		Max.	126.3	106.7	111.1	105.9	111.1	104.8	105.7	102.–

The peculiarities shown by the Indian teeth are, first, their large size. The teeth of the Sioux, taken as a whole, exceed in the average all others on record, and those of Arkansas are not far behind.

The crown index in three of the groups (Sioux, Pueblos, Arkansas) is, in general, remarkably like that of the white and other races, pointing in its turn to fundamental family unity. One of the groups, however, the Green River Kentucky people, is strikingly exceptional. It shows a higher crown index than any other groups examined or recorded. The teeth are very stout. As a result, in the 80 teeth of the 20 males only

two, one first and one second molar, in as many individuals, show a crown index below 100; while among the women where, as will be shown later on, the teeth are relatively longer, the number of indices below 100 is 10 with the first and 8 with the second molar, in 7 individuals. In all other cases the teeth are hyperbrachydont. The cause of this exceptional showing may possibly be the following. These people, of whom, thanks to the careful work of Mr. Clarence B. Moore, the collector, we possess a fine series of skeletons, were people of *subaverage* strength for the Indian. Their bones and even skulls are rather delicate for a primitive stock, though free from all signs of disease or abnormality. Whatever the causes of this, the condition can only be regarded as a reduction of a former stronger build; and it is possible that the jaws, participating in this reduction, influenced the development of the teeth in their length, while the breadth was unaffected. The relative stoutness of the teeth was plainly not due to excessive use, and so the above appears as about the only plausible explanation. However, whatever the cause of the condition, the fact remains that in one race in a group the teeth may develop marked differences in absolute as well as relative dimensions from those of the rest of the group.

SEX

The sexual differences in the two molars are remarkable. Taking all the human groups together, we obtain the following percental relations in the dimensions of the teeth in the two sexes, the male measurements being taken as *100*: M_1–L. 99.2, B. 96.6; M_2–L. 97.15, B. 96.55. The female teeth are shorter than those of the males, and they are especially less broad. A more correct statement of the facts, however, probably is that based on the breadth, in which case we should say that, while on the whole the female molars are absolutely narrower as well as shorter than those of the males, relatively they, and particularly the M_1, are longer than they should be if they preserved towards the male teeth the same ratio in both dimensions. The male first molars are stouter, but not correspondingly as long as they ought to be if preserving the same relations.

The result of the sexual differences just dealt with is a markedly lower crown index in the female of the M_1. The crown indices for the whole human family (as far as represented in our records) are respectively, for M_1, males *98.3*, females, *95.8*. As to M_2, conditions differ; the index on the whole is almost the same in the two sexes (*98.1*, *97.7*).

A glance at the detailed data will show that, for M_1, the sexual differences hold true for all the racial groups with very few slight exceptions. In actual length in two of the main series (the American Whites and the Melanesians), the female tooth is actually even absolutely a trace longer, in consequence of which the index in these two groups is lower than in any of the others. As to M_2, conditions differ somewhat. The tooth is absolutely shorter as well as narrower in the females of all the groups, but the relative value of the two diameters as shown by the crown index, differs somewhat from group to group. The index is decidedly smaller than in the males only in the white females; in the remaining groups it is almost the same in the two sexes, and in some it even tends to a slight excess in the females. All this is due to the fact that the M_2 tends to be not only absolutely but also relatively *shorter* in the females than the M_1. This, though not so marked, is an opposite condition to that of M_1 which in the females tends plainly to be relatively longer than in the males. These conditions will be seen even clearer in the next section. In interpretation of these rather involved conditions, the following may be offered: The absolutely smaller size of the female molars may, it seems, be safely attributed to the physiological cause of somewhat lesser work of the female teeth, due to not quite as heavy jaws or strong muscles as those of males. As to the peculiarities in the relative dimensions of the teeth, assuming, as we are justified in doing (see further), that a long tooth is nearer the ancestral form and hence a more primitive tooth, it appears that the M_1 deserves to be regarded as somewhat more primitive in the females, the M_2 as tending to a slightly greater primitiveness in the males.

TOOTH

The two molars we are dealing with are, as just shown, not equal in man either in absolute or relative proportions. In the anthropoid apes, as will be seen further on, the second lower molar is generally larger than the first. In Early Man,[1] the M_2 is still a trace to perceptibly larger than the M_1 in the Piltdown, Mauer, Šipka, Le Moustier (left side), Ehringsdorf adult, Ehringsdorf juvenile, the large Krapina, the Ochoz, the Obercassel male and the Obercassel female (right side) jaws; hence, in all the older and in a large majority of the more recent diluvial remains where the lower molars are preserved. A larger M_2 than M_1 in man of

[1]See this *Journal*, VI, No. 2

to-day is exceptional. The actual conditions[2] found in the present studies are as follows: The mean modules of the teeth $\frac{(L+B)}{(2)}$ show that, on the average, the first lower molar is larger than the second in every racial group and in both sexes.

THE MEAN DIAMETER, OR MODULE, OF THE LOWER M_1 AND M_2

	Males						Females					
	American Whites	Old Egyptains	Indians	Eskimo	Negroes	Melane-sians	American Whites	Old Egyptains	Indians	Eskimo	Negroes	Melane-sians
M_1 Mean Diam.	10.53	10.51	11.28	11.13	11.03	11.24	10.46	10.24	10.78	10.99	10.69	11.15
M_2 do	10.32	10.31	10.93	10.95	10.77	10.84	10.09	10.08	10.30	10.63	10.57	10.41
Relation of the Above (M_1=100)	*98.–*	*98.1*	*96.9*	*96.6*	*97.6*	*96.4*	*96.5*	*98.4*	*95.6*	*96.7*	*98.9*	*93.4*

The mass relation of the two teeth is on the whole closely alike in the different groups. In the males the two teeth show practically identical conditions in the Whites and Old Egyptians, while on the other hand there is a good deal of similarity in the colored races. The difference between the Whites with the Egyptians on one side and the colored groups,is due to a relatively (besides absolutely) smaller M_1 in the former.

In the females somewhat exceptional conditions are shown by the Egyptians (relatively small M_1), the Negro (relatively small M_1) and in the Melanesians (relatively large M_1). These and other peculiarities shown by the data may, unless accidental, probably be attributed to slight evolutionary differences in these respects in the various groups.

The next table presents the more important data on the relation of the molars in individuals:

[2]See also de Terra (Max)—Beiträge z. Odontographie d. Menschenrassen. 8°, 1905.

RELATION OF M_1 TO M_2 IN SIZE, IN MAN

		Whites		Egyptians		Indians, Ky.		Other Indians		Eskimo		Negroes		Melanesians	
		Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Number of pairs compared		40	40	40	20	40	40	60	60	40	40	20	20	20	20
M_1 longer & as broad as or a trace stouter than M_2		Per cent:													
	r.	*55*	*90*	*80*	*70*	*55*	*80*	*70*	*90*	*80*	*65*	*70*	*60*	*80*	*100*
	l.	*60*	*80*	*80*	*80*	*55*	*90*	*70*	*83*	*75*	*70*	*60*	*50*	*90*	*90*
M_1 & M_2 equal in length and breadth	r.	20	5	5	10	10	10	17	3	—	10	20	20	20	—
	l.	20	10	5	—	5	10	17	7	10	10	20	30	10	10
M_2 trace to slightly longer than M_1	r.	15	—	—	—	10	—	3	—	10	10	—	—	—	—
	l.	15	—	—	—	10	—	3	—	10	10	—	—	—	—
M_2 trace to slightly broader than M_1	r.	5	5	5	—	10	—	7	7	5	5	10	10	—	—
	l.	—	10	5	10	10	—	7	7	5	5	20	10	—	—
M_2 larger in both directions	r.	5	—	10	20	15	10	3	—	5	10	—	10	—	—
	l.	5	—	10	10	20	—	3	3	—	5	—	10	—	—

	Pairs (M_1+M_2)	M_1 larger per cent	M_1 & M_2 equal per cent	M_2 larger (in any dimension) per cent	M_2 greater in length	M_2 greater in breadth	M_2 larger in both length
TOTALS: Male	260	*69.2*	*12.30*	*18.45*	*6.15*	*6.15*	*6.15*
Females	240	*80.–*	*8.75*	*11.25*	*1.67*	*5.—*	*4.58*
ALL HUMAN	250	*74.6*	*10.6*	*14.85*	*4.—*	*5.6*	*5.4*

In three-fourths of the cases in present man, the first molar is larger than the second; in a little over one-tenth the two teeth are equal and in but a little over one-sixth of the pairs the M_2 is a trace to slightly larger either in length or breadth or both, or in one-ninth if we take teeth larger in both dimensions, than M_1—a great difference from ancestral conditions.

The males on the whole show more of the primitive condition of M_2 larger than M_1. This is due on one hand to the relatively long M_1 in the females, and on the other to a greater frequency in the male of a relatively long M_2—conditions that have already been spoken of in the preceding chapter.

The smallest proportion of cases in which M_2 exceeds M_1 in both length and breadth is found in the Whites, the largest in the otherwise so closely related Egyptians, and in some Indians (Sioux, Ky.). The Egyptians thus show a difference from the present-day Whites in the direction of a

somewhat greater primitiveness, which is what might have been expected. The good showing of the Negroes and Melanesians is a surprise which is rather hard to understand.

SIDE

A few words remain to be said about the differences of M_1 and M_2 on the two sides.

Individual slight differences in size between the right and left teeth are common; but collectively, as will be seen below, matters are largely evened up.

RELATION OF THE RIGHT AND LEFT TEETH IN SIZE

CROWN MODULE

	Males						Females					
	Whites	Egyptians	Indians	Eskimo	Negroes	Melanesian	Whites	Egyptians	Indians	Eskimo	Negroes	Melanesian
Lower M_1												
Right	10.55	10.50	11.27	11.15	11.08	11.19	10.45	10.25	10.79	10.97	10.80	11.17
Left	10.51	10.53	11.30	11.11	10.98	11.29	10.48	10.23	10.78	11.01	10.63	11.13
Lower M_2												
Right	10.35	10.30	10.92	10.98	10.78	10.85	10.08	10.07	10.25	10.63	10.58	10.39
Left	10.30	10.33	10.94	10.93	10.77	10.83	10.10	10.10	10.35	10.63	10.57	10.43

All Human

M_1					M_2				
Right,	Males	10.96;	Females	10.74	Right,	Males	10.70;	Females	10.33
Left	"	10.95	"	10.71	Left	"	10.68	"	10.36

Taking the human material as a whole, it is seen that as to mass, there is a very slight tendency in favor of the right teeth, except in F. M_2 where this tendency is reversed. More in detail we may note various interesting conditions which however are too slight to be discussed, at least so until corroborated on additional material.

The exceedingly close agreement of the teeth even in almost infinitesimal details in the different racial groups, is simply so much more of demonstration of the unity of the human species and the similarity of the evolutionary and involutionary processes in the various and otherwise apparently far separated groups of man.

The individual differences in the lower molars on the two sides, are numerous, and there appears to be something characteristic in them in the various groups:

LOWER M_1 AND M_2 ACCORDING TO SIDE

	Males						Females					
	Whites	Egyptians	Indians	Eskimo	Negroes	Melanesians	Whites	Egyptians	Indians	Eskimo	Negroes	Melanesians
M_1	*Per cent:*											
R. longer.....	10	5	20	25	—	10	—	30	14	5	20	20
R. longer & narrower...	5	5	—	5	—	—	—	—	2	—	—	—
R. broader....	—	—	2	—	10	—	5	—	2	—	10	—
R. longer & broader....	—	—	2	—	10	—	—	—	2	—	20	—
Equal........	85	45	62	45	80	60	85	30	60	65	50	70
L. longer.....	—	10	8	5	—	—	—	—	—	5	—	—
L. longer & narrower...	—	5	—	—	—	—	—	—	—	—	—	—
L. broader....	—	25	6	15	—	10	10	30	18	25	—	—
L. longer & broader....	—	5	—	5	—	20	—	10	2	—	—	10
M_2												
R. longer.....	15	—	8	15	—	—	—	10	2	10	20	10
R. longer & narrower...	—	15	4	—	10	10	—	10	—	—	—	10
R. broader....	10	—	8	5	—	—	—	—	14	—	10	—
R. longer & broader....	5	5	2	5	—	—	—	10	2	5	—	—
Equal........	60	40	60	60	90	90	85	10	46	55	40	70
L. longer.....	10	5	2	5	—	—	5	10	6	—	10	10
L. longer & narrower...	—	—	—	—	—	—	—	—	—	—	10	—
L. broader....	—	30	12	10	—	—	10	50	20	30	10	—
L. longer & broader....	—	5	4	—	—	—	—	—	10	—	—	—

The above data show that, as to M_1, the teeth vary least on the two sides in the Whites, most in the Egyptians; the M_2 varies least in the male Blacks and female Whites, most again in the Egyptians (of both sexes). The nature of the differences is also quite unlike in some of the groups. In the Negroes the frequency of the right tooth exceeding in one or both dimensions the left, seems to be the rule in the males and almost so in the females; while the Egyptians present the reverse condition, the left tooth, where there is difference, being generally larger than the right. In general the exceptional variability of the Egyptian teeth may possibly be connected with their derivation from the upper classes; but the frequency of excess in the left teeth looks more like a group peculiarity. In this connection it is seen once more that in details the Egyptian teeth differ from those of present-day Whites, even though showing a greater similarity to them than those of any other racial group here dealt with in gross average dimensions.

ANTHROPOID APES

Conditions in regard to absolute and relative dimension of the first and second lower molars in the anthropoid apes, differ much from those in man, and yet there is also a good deal of likeness.

SPECIES

The teeth differ greatly in almost every respect between the different species. The principal facts so far as the dimensions of the teeth are concerned, obtained on the fine series of material in the Division of Mammals, U. S. National Museum, are shown in the following table:

VARIATION IN DIMENSIONS OF FIRST AND SECOND LOWER MOLARS: ANTHROPOIDS

			Male					Females				
						Gibbons					Gibbons	
1st MOLAR			Chimpanzees	Gorillas	Orangs	Symphalangus	Hylobates	Chimpanzees	Gorillas	Orangs	Symphalangus	Hylobates
			(10)	(20)	(20)	(4)	(10)	(10)	(2)	(20)	(4)	(4)
			mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
Right	Length	Av.	**10.63**	**15.40**	**13.63**	**8.55**	**6.01**	**10.35**	**14.25**	**12.53**	**7.62**	**5.80**
		Min.	10.5	13.—	12.—	8.2	5.5	10.—	14.—	11.—	7.—	5.2
		Max.	11.3	17.5	15.—	9.—	6.5	11.—	14.5	13.5	8.5	6.5
	Breadth	Av.	**9.80**	**13.44**	**12.68**	**6.62**	**4.93**	**9.60**	**11.45**	**11.33**	**6.12**	**5.02**
		Min.	9.—	12.—	12.—	6.5	4.7	9.—	11.2	10.5	5.5	4.8
		Max.	10.5	16.—	14.5	7.—	5.2	10.5	11.7	12.5	6.5	5.5
	L-B Index	Av.	**92.2**	**87.2**	**93.—**	**77.5**	**82.–**	**92.7**	**80.4**	**90.4**	**80.3**	**86.6**
		Min.	*86.4*	*79.4*	*85.7*	*72.2*	*76.9*	*90.—*	*77.2*	*83.3*	*76.5*	*76.9*
		Max.	*100.–*	*96.8*	*100.–*	*82.3*	*86.2*	*95.5*	*83.6*	*100.–*	*86.7*	*92.3*
Left	L	Av.	**10.63**	**15.23**	**13.68**	**8.55**	**6.01**	**10.25**	**14.25**	**12.43**	**7.62**	**5.67**
		Min.	10.—	13.—	12.5	8.2	5.5	10.—	14.—	11.—	7.—	5.2
		Max.	11.3	18.—	16.—	9.—	6.5–	11.—	14.5	13.5	8.5	6.—
	B	Av.	**9.80**	**13.48**	**12.80**	**6.65**	**4.97**	**9.60**	**11.45**	**11.38**	**6.25**	**5.07**
		Min.	9.—	12.—	12.—	6.5	4.7	9.—	11.2	10.—	5.8	4.8
		Max.	10.5	16.—	15.—	6.8	5.2	10.5	11.7	12.5	6.7	5.3
	I	Av.	**92.2**	**88.6**	**93.2**	**77.8**	**82.7**	**93.6**	**80.4**	**91.5**	**82.–**	**89.4**
		Min.	*86.4*	*81.2*	*86.2*	*72.2*	*80.–*	*90.—*	*77.2*	*84.6*	*78.8*	*86.7*
		Max.	*100.–*	*96.8*	*104.–*	*82.9*	*86.2*	*100.–*	*83.6*	*100.–*	*86.7*	*92.3*
2nd MOLAR Right	L	Av.	**10.90**	**17.28**	**14.4**	**9.05**	**6.42**	**10.55**	**16.25**	**12.73**	**8.40**	**6.20**
		Min.	10.–	14.5	13.—	9.—	6.—	9.—	16.—	11.5	7.3	5.5
		Max.	11.5	20.—	16.—	9.2	7.—	11.5	16.5	14.—	9.3	7.—
	B	Av.	**10.37**	**15.10**	**13.78**	**7.30**	**5.56**	**9.95**	**13.10**	**12.10**	**6.80**	**5.37**
		Min.	9.—	13.5	13.—	7.—	5.2	9.—	13.—	11.—	6.5	4.8
		Max.	11.5	18.—	17.—	7.5	6.—	11.—	13.2	13.—	7.2	6.—
	I	Av.	**95.1**	**87.4**	**95.7**	**80.7**	**86.6**	**94.3**	**80.6**	**95.5**	**81.–**	**86.6**
		Min.	*90.—*	*79.4*	*86.7*	*77.8*	*83.9*	*90.—*	*78.8*	*88.—*	*76.5*	*84.6*
		Max.	*100.–*	*94.1*	*106.2*	*83.3*	*93.3*	*100.–*	*82.5*	*104.3*	*89.–*	*89.7*
Left	L	Av.	**10.90**	**17.25**	**14.38**	**8.92**	**6.42**	**10.55**	**16.—**	**12.65**	**8.40**	**6.20**
		Min.	10.—	14.5	13.—	8.7	6.—	9.—	15.5	11.—	7.3	5.5
		Max.	11.5	20.—	16.—	9.—	7.—	11.5	16.5	14.—	9.3	7.—
	B	Av.	**10.36**	**15.19**	**13.70**	**7.22**	**5.62**	**10.—**	**13.10**	**12.20**	**6.80**	**5.50**
		Min.	9.—	13.2	13.—	7.—	5.2	9.—	13.—	11.—	6.5	5.—
		Max.	11.5	18.—	16.5	7.5	6.2	11.—	13.2	13.—	7.2	5.8
	I	Av.	**95.—**	**88.—**	**95.3**	**80.9**	**87.5**	**94.8**	**81.9**	**96.4**	**81.—**	**88.7**
		Min.	*90.—*	*82.3*	*86.7*	*80.–*	*83.9*	*87.—*	*78.8*	*88.9*	*76.5*	*82.9*
		Max.	*100.–*	*94.3*	*103.6*	*83.3*	*93.3*	*100.–*	*85.2*	*106.6*	*89.–*	*94.8*

Taking the mean mass of the two teeth in the several species regardless of sex, we obtain the following sequence: Gorillas—14.52; Orangs—12.90; Chimpanzees—10.26; *Symphalangus synd.*—7.55; and Gibbons—5.68 (Man—10.68). Some of the individual teeth in the Gorillas are enormous (the teeth of No. 176,204 reach for M_1, L.—17.—, B. 16.—; for M_2, L.—20.—, B. 18.— mm., mean module 17.75).

The mean index also differs considerably. The mean index in man is close to *96.5;* it is *94.*— in the Chimpanzees, *93.9* in the Orangs, *86.3* in the Gibbons, *84.3* in the Gorillas, and *80.4* in the Symphalangus. Variability in the index, as in the absolute measurements, is on the whole astonishingly near to what it is in man. It is, for some reason, most marked in the Orangs; in this species the entire molar part of the denture is very variable.[1] Both in size and index the nearest to human teeth are those of the Chimpanzee; but this in all probability is a similarity of acquisition rather than a genetic relationship, though the ancestral teeth of both forms may have been closely related.

SEX

The mass of the two molars as represented by their mean module $\left\{\frac{LL+BB}{4}\right\}$ in the females compares with that of the males (these being taken as 100), thus: Man—97.4; Gibbons—97.5; Chimpanzees—96.8; Symphalangus—92.3; Gorillas—89.7; Orangs—89.3. The male molars in the last two named species, as the canines and as in fact the whole skull, show what may perhaps be termed a relatively high degree of bestialization. The sexual differences are not the same in the two molars, nor are they the same in the two dimensions of the teeth in all the species, but these points will be dealt with later.

The crown index in man was seen to present characteristic sexual differences for the first molar; due to a relatively greater length of the first molar in the female, the index in this sex in practically all the racial groups whose teeth were measured, was found to be a trace to markedly lower than that in the males. In the anthropoid apes conditions differ. In the Gorillas and Orangs the index of M_1 is lower in females, as in man, but in the Chimpanzees and especially the Symphal-

[1]See author's "Anatomical observations on a Collection of Orang Skulls from Western Borneo." Proc. U. S. National Museum, XXXI, No. 1495, Wash., 1906.

angus and Gibbons, the condition is reversed. The Chimpanzee differs here from man. His female M_1 is, however slight the defect may be, relatively short, which is the opposite to what prevails in the human female. In the Gorilla and the Orang, as compared to the Chimpanzee, it will be seen that the male M_1 is relatively stout but also that the female tooth is relatively long. In the Symphalangus and the Gibbons, the female M_1 is relatively short.

As to the crown index of the second molars, conditions in the anthropoid apes are much alike in the two sexes with the exception of the Gorilla, in which, due to the relatively great length of the female M_2, the index of this tooth, as in the case of the M_1, is considerably lower than that in the males of the species.

TOOTH

The mass differences between the lower M_1 and M_2 are much more accentuated in the anthropoid apes than they are in man, and that in an opposite direction, the M_2 being generally the larger. The relations of the module of the two teeth in man and the different species of great apes appear thus ($M_2 = 100$): Man (in general)—*103*.—; Chimpanzees —*96.3;* Orangs—*94.9;* Symphalangus—*92.1;* Gibbons—*91.9;* Gorillas —*88.4*. The Gorilla, in this respect, is the farthest from the condition in man.

In detail, in the 20 male and 2 female *Gorillas* the second molar was found invariably the larger in both length and breadth.

In the *Chimpanzees* in 3 of the 10 males the two molars were of equal size on both sides; in 1 of the 10 females they were equal on the right; in 1 female, the second molar, while equally broad, was by 1 mm. shorter on each side than the corresponding M_1.

In the *Orangs* all the 20 males showed M_2 larger; among the 20 female Orangs however, in 1 the two teeth were equal on both sides, and in 4 the M_1 was slightly longer while the M_2 was slightly broader, on each side.

In the *Symphalangus*, the M_2 exceeds M_1 in both length and breadth in every instance.

In the *Gibbons*, in 1 female, on both sides the two teeth were equal; in 1 male they were equal in length but not in breadth; in all the other cases the M_2 was larger in both length and breadth than the M_1.

RELATION, IN LENGTH AND BREADTH OF THE LOWER FIRST AND SECOND MOLARS IN THE TWO SEXES

	M_1 (R+L)						M_2 (R+L)					
	Man	Chimpanzees	Gorillas	Orangs	Symph. synd.	Gibbons	Man	Chimpanzees	Gorillas	Orangs	Symph. synd.	Gibbons
Male—												
Length	*11.05*	10.63	15.31	13.65	8.55	6.01	*10.79*	10.90	17.26	14.39	8.98	6.42
Breadth	*10.86*	9.80	13.46	12.74	6.63	4.95	*10.58*	10.36	15.14	13.74	7.26	5.59
Female–												
Length	*10.95*	10.30	14.25	12.48	7.62	5.73	*10.49*	10.55	16.12	12.69	8.40	6.20
Breadth	*10.48*	9.60	11.45	11.35	6.18	5.04	*10.22*	9.97	13.10	12.15	6.80	5.43
Male vs. Female in length	**99.2**	*96.9*	*93.—*	*91.4*	*89.1*	*95.4*	**97.1**	*96.8*	*93.4*	*88.–*	*93.9*	*96.6*
Male vs. Fem. in breadth	**96.6**	*98.–*	*85.1*	*89.1*	*93.2*	*101.9*	**96.5**	*96.2*	*86.5*	*88.4*	*93.7*	*97.2*

Particulars as to the relation of the two teeth in the separate measurements in the sexes, are given below; in connection with future studies they may possibly assume some significance.

As to the index, conditions of the two teeth are briefly these:

MEAN CROWN INDEX (BOTH SEXES)

	M_1	M_2		M_1	M_2
Chimpanzees	92.7	94.8	Gibbons	85.2	87.3
Orangs	92.—	95.7	Gorillas	84.1	84.5
			Symphalangus	79.4	80.9

The index of the second molar averages invariably higher than that of the first—least so in the Gorillas, most so, as with other variations, in the Orangs.

SIDE

In man there was a wide tendency in both M_1 and M_2 towards a slightly greater stoutness on the left side. In the anthropoids there is somewhat greater equality, and where this does not exist there is a rather marked compensative tendency between the two teeth on the two sides. The details, which do not need further discussion, follow. Details showing the small differences of the index on the two sides may be seen in the general table.

MODULE $\frac{L+B}{2}$ OF M_1 & M_2 IN ANTHROPOID APES, ACCORDING TO SEX AND SIDE

	Males					Females				
	Chimpanzees	Gorillas	Orangs	Symphal. synd.	Gibbons	Chimpanzees	Gorillas	Orangs	Symyh. synd.	Gibbons
M_1 Right	10.21	14.42	13.16	7.58	5.47	9.92	12.85	11.93	6.87	5.41
Left	10.21	14.36	13.24	7.60	5.49	9.92	12.85	11.91	6.93	5.37
Mean Module of M_1	*10.21*	*14.39*	*13.20*	*7.59*	*5.48*	*9.92*	*12.85*	*11.92*	*6.90*	*5.39*
M_2 Right	10.64	16.19	14.09	8.17	5.99	10.25	14.67	12.42	7.60	5.79
Left	10.63	16.22	14.04	8.07	6.02	10.27	14.55	12.43	7.60	5.85
Mean Module of M_2	*10.63*	*16.21*	*14.0*	*78.12*	*6.01*	*10.26*	*14.61*	*12.42*	*7.60*	*5.82*
M_1 vs. M_2 (M_2=100)	**96.–**	**88.8**	**93.8**	**93.5**	**91.2**	**96.7**	**88.–**	**96.–**	**90.8**	**9.26**

RESUMÉ AND CONCLUSIONS

A study, in man and the anthropoid apes, of the two principal dimensions of the crown in the lower first and second molars—which are about the most stable and representative of all the molars—reveals a series of hitherto unknown or but partly known facts of phylo- as well as ontogenetic interest, which may be summarized as follows:

In their actual and especially in their relative proportions, the lower M_1 and M_2 in man stand well apart from those of the anthropoid apes; yet the gap is not very great, it is crossed by individual teeth from both sides, and it is bridged over to a large extent by the teeth of the early forms of man.

The resemblances and differences between the teeth of modern man and those of the anthropoid apes are not necessarily nor even probably, except in fundamentals, the ancestral relations, but are rather to be looked upon as parallel or divergent developments.

The most human-like teeth among the anthropoid apes are those of the chimpanzee, but this, as just said, does not necessarily mean a close genetic relation, for the teeth of man of to-day (as well as those of the chimpanzee) are not those of their early ancestry. Nevertheless, the similarities in size and to a large extent even in the crown index between the teeth of the two forms, is a very interesting phenomenon, and probably indicates a much closer relation in man and this ape in such habits as have influence on the size and form of the teeth, than has hitherto been appreciated.

The most radical present-day difference between these molars in man and the apes, lies in the relative mass of the two teeth; in man the M_2 being generally smaller than M_1, while in the apes the M_2 is as a rule the larger. Judging from the teeth of Early Man the latter condition appears to be the older and to have existed also in man's ancestry.

The second important difference between these teeth in man and the apes, is their relative shortness in man, which gives rise to a high crown index. In some human groups, this relative shortness of the teeth is such that their average breadth actually exceeds the average length.

Sexual differences in the teeth under consideration are more pronounced in the apes and that particularly in the Gorillas and Orangs, than they are in man. On the other hand, man shows in general a rather primitive, relatively long M_1 in the females, which is much less the case in apes. This is well reflected in the crown index of these teeth which as a rule is smaller in the females than in the males in man, but is smaller in the females of some species while equal or larger in other species, in apes.

There is enough in common in the detailed characteristics of the lower molars alone, as far as dealt with in this study, strongly to support the opinion of the far-ancestral unity of the whole Primate group, including the forebears of man.

Among the apes the outstanding features of the lower M_1 and M_2 are:

(a) The great size and especially length of the teeth in the Gorilla, with a great difference in the species in the crown index of the two sexes;

(b) Their great variability in all respects in the Orang; and

(c) The marked differences both in absolute and relative proportions of the teeth of the Symphalangus and the Gibbons. These would appear to be more of a family or at least of a sub-family nature than merely those of species or genera.

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